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Holston River Study Appendix E

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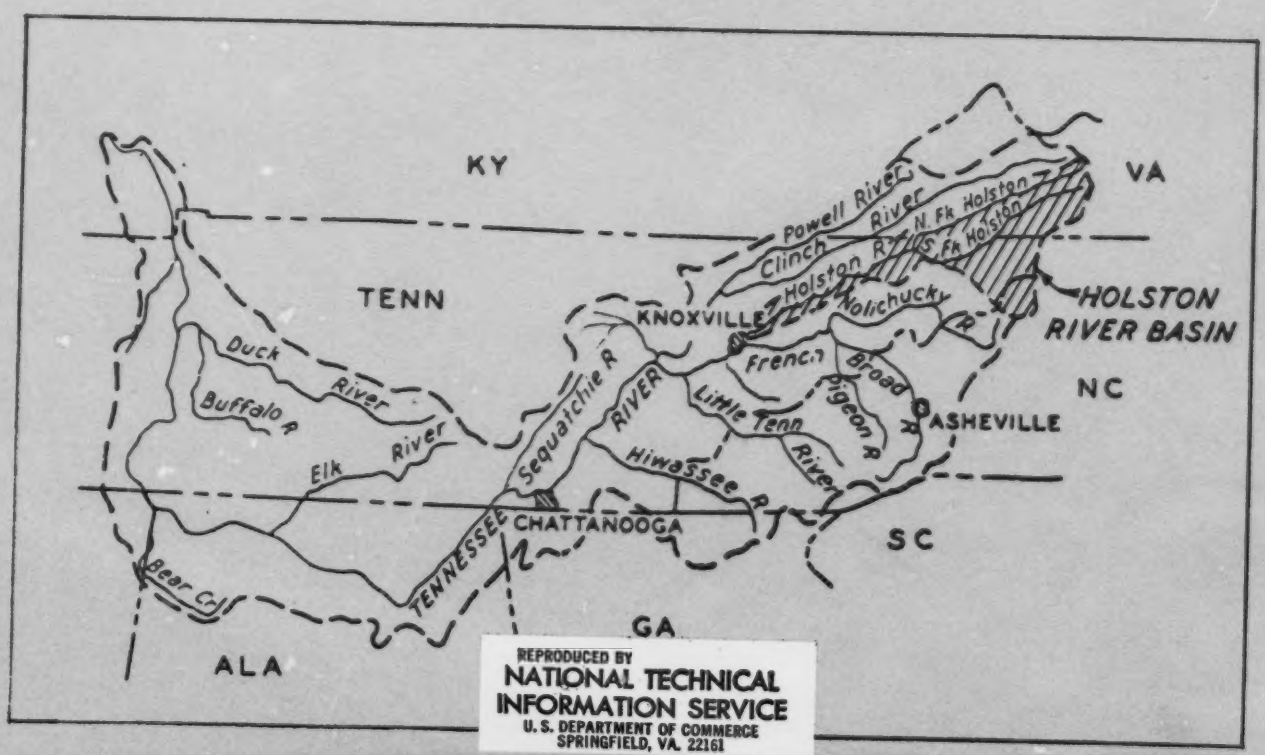

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Appendix E contains information about the QUAL II Water Quality Model and its use in modeling dissolved oxygen, BOD, nitrogen and phosphorus.

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APPENDIX E

QUAL II WATER QUALITY MODEL

INTRODUCTION

The Holston River from HRM 118 to the confluence of the North and South Fork, the South Fork Holston River to Fort Patrick Henry Dam, and a short reach of the North Fork Holston River was simulated using the QUAL-II water quality model (Roesner et al., 1973). The effects of biochemical oxygen demand and nitrogen compounds from waste discharges and respiration of aquatic plants on the oxygen balance of the stream were simulated. The purpose of this effort was to assess the water quality of the Holston River relative to current waste discharges and aquatic plant populations.

SUMMARY OF EARLIER WORK

In June and July 1969, an intensive field study of the upper Holston River system was conducted by personnel of the Federal Water Quality Administration (later to become part of the U. S. Environmental Protection Agency), the Tennessee Valley Authority, and the Tennessee Department of Public Health (EPA, 1972). The purpose of the study was to develop

recommendations for waste abatement and water quality management in the basin. At that time, approximately 137,500 lbs/day of five-day biochemical oxygen demand (BOD_5) and nitrogenous wastes with a potential oxygen demand of 84,000 lbs/day were being discharged to the South Fork and Holston Rivers. Attached aquatic vegetation and extensive sludge beds with considerable benthic oxygen demand were observed in the Holston River from Kingsport downstream to the headwaters of the Cherokee Reservoir. Temperature in the South Fork was increased by more than 11°C by cooling water discharges from Tennessee Eastman Corporation (TEC) and Holston Army Ammunition Plant (HAAP). The report recommended wasteload reductions equivalent to 92% treatment of untreated BOD_5 and Total Kjeldahl Nitrogen (TKN) for all dischargers and the adoption of cooling techniques by TEC and HAAP.

The upper reaches of the Holston River system have been the subject of several somewhat independent water quality modeling attempts since 1969. EPA and TVA jointly developed a model following their 1969 water quality investigations (EPA,

1972). TVA later refined this model to include the effects of photosynthesis and respiration by aquatic plants and other factors on the dissolved oxygen budget in the streams (TVA, Unpublished). In 1973, TEC retained a consultant, Peter A. Krenkel, to independently model the rivers in an effort to refute (or verify) the published results of the EPA/TVA model (Krenkel & Novotny, 1973). The EPA and TEC reports each recommended seperate waste discharge amounts that would not violate dissolved oxygen standards of 3 and 5 mg/L.

MODEL STRUCTURE

The Holston River system was divided into 14 reaches for simulation. The model structure is shown in Figure E-1. The South Fork Holston River from SFHRM 0.0 to SFHRM 8.0 (approximately the location of Ft. Patrick Henry Dam), a short reach of the North Fork Holston River, and the Holston River from HRM 118 to HRM 142.2 (the confluence of the North and South Forks) is included in the model. The 14 reaches of the system are further divided into 0.2 mile long computational elements. Waste discharges from the Tennessee Eastman

Corporation, the Holston Army Ammunition Plant Areas A and B, Mead Paper Corporation, the City of Kingsport, and Holliston Mills are included in the model.

Model inputs are discussed in the general order in which they appear in the input stream. A listing of a complete computer simulation, including input, is at the end of this report.

ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS

The only two constants of interest to this simulation contained in this input block are the oxygen uptake by oxidation of NH_3 to NO_2 and NO_2 and NO_3. The values were specified as 3.22 mg O_2/mg NH_3 and 1.12 mg O_2/mg NO_2. The total oxygen uptake by NH_3 oxidation to NO_3, then, is 4.34 mg O_2/mg NH_3. This value is slightly less than the stoichiometric coefficient of 4.57 mg. The lower value is used because some oxygen is produced during CO_2 fixation in protoplasm synthesis (Wezernok & Gannon, 1967). The remainder of the constants in this data block relate to the simulation of algae. Although algae were not simulated, typical values

were inserted in the fields. QUAL-II does unit conversions on some constants and otherwise uses them in preliminary computations regardless of whether they are used later or not. Zero values in these fields can cause computational problems.

HYDRAULIC COEFFICIENTS FOR DETERMINING VELOCITY AND DEPTH

The hydraulic coefficients for velocity and depth are used in the relationships:

$$V = a_1 Q^{b_1}$$

and

$$D = a_3 Q^{b_2}$$

where V = velocity, fps

Q = streamflow, cfs

D = depth, ft

The coefficients of the velocity relationship were calculated to fit the time of travel measurements made during the 1977 EPA survey. The exponent b_1 was reported in the report of the 1969 EPA survey as 0.674 from the confluence of the North

and South Forks to HRM 131.5 and 0.539 from HRM 131.5 to HRMM 118.4. The value of a_1 was calculated to fit the measured flow and velocity. The results are presented in Table E-1.

The width and depth measurements made during the EPA surveys in 1969 and 1977 were used to compute average values for input to the model. These measurements are presented in Table E-2. Although width is not input directly to the model, it is important in the computation of benthal demand.

An attempt was made to fit the 1977 EPA data to the power curve of flow versus depth, but the regression analysis indicated no relationship. Figure E-2 shows the data and fitted curve. The r^2 value of 0.009 is not significant.

Figure E-3 is a plot of the depth measurements versus HRM. Above HRM 131.4, the depth measurements consistently fall between 2.0 and 3.0 feet (except for the single measurement of 5.57 feet at HRM 136.2). The mean of these measurements, 2.6 feet, was used in the model. Below HRM 131.4, considerable variability is evident in the measurements. The mean of these measurements, 4.8 feet, was input to the model.

Figure E-4 compares the assumptions for depth made in this study with the studies of TVA and Krenkel and Novotny (Table E-3). Krenkel and Novotny's depths were based on measurements made during the 1969 EPA survey and TVA surveys in 1945 and 1969. TVA computed an equivalent depth for their model from time-of-travel measurements and widths scaled from topographic maps. The equation of continuity was used to compute the equivalent depth. It can be seen that the EPA data of 1969 and 1977 are consistent with Krenkel and Novotny's assumptions above HRM 131.4, but that TVA's computed depths are not supported by field data. The TVA assumptions are apparently the same used in the 1969 EPA model.

Width measurements versus river mile are plotted in Figure E-5. The mean of the measurements, 445 feet, was used in the benthal demand calculations for the Holston River. An estimate of the width of the South and North Forks was available from remote sensing data. A total river area of 68 hectares for 4.5 stream miles was reported, giving an average width of approximately 308 feet.

REACTION COEFFICIENTS-DEOXYGENATION AND NITROGEN OXIDATION

The reaction coefficients for deoxygenation and nitrogen oxidation are usually evaluated from results of a water quality survey. However, the variability of the data from the 1977 survey made the results of such an analysis inclusive. This variability may be the result of incomplete mixing at the stream sampling stations at SFHRM 1.2 and HRM 141.2. The most striking inconsistency in the data is the fact that the highest BOD_5 and highest mean BOD_5 occurred at the station at SFHRM 5.6, supposedly above all waste discharges. Furthermore, all except one BOD_5 value (the high value of 6.4 mg/L at SFHRM 5.6) are below 3.5 mg/L, quite low values for a "polluted" stream. The earlier modeling reports were examined for approximate values of the deoxygenation coefficient. The TVA model report contained a good discussion of the variability encountered in computing deoxygenation coefficients in the Holston River and presented a rational method for resolving the matter. Therefore, the deoxygenation coefficients used by TVA were used in this model. TVA calculated a 20°C deoxygenation coefficient of 0.76/day upstream of HRM 137.9 and 0.32/day downstream of HRM 137.9.

The oxidation rate for NH_3 was estimated from the mean concentrations reported in the water quality survey and the reported time of travel. The rate was computed from the mean NH_3 concentrations of 0.47mg/L at HRM 139.2 and 0.31 mg/L at HRM 126.6. The time of travel between the two stations was reported as 23 hrs, 14 min. The computational formula used was:

$$k = -\ln(N/N_0)/(t-t_0)$$

where k is the rate coefficient, N_0 is the NH_3 concentration at time t_0 and N is the concentration at time t. The average temperature of the observed data was assumed to be 26.7°C. The rate coefficient was adjusted to 20°C using the relationship:

$$K_T = K_{20}(1.047)^{T-20}$$

where T is temperature in °C. Using this procedure, the computed rate coefficient was 0.30/day. An NO_2 oxidation coefficent of 0.50/day was assumed. This coefficient is not critical to the model predictions as NH_3-NO_2 oxidation is the rate-limiting step.

REACTION COEFFICIENTS-REAERATION

The selection of a prediction model for stream reaeration is often difficult. Several prediction equations have been developed over the years and all tend to give somewhat different results. Covar (1976) recently reviewed several prediction equations and developed a rationale for selecting the appropriate relationship for a specific application. This selection methodology, summarized in Figure E-6 taken from Covar's paper, is based on the data which were used to calibrate each prediction equation. The selection criteria are based on the independent variables of the prediction equations, velocity and depth. In the part of the Holston modeled in this study, velocity ranges of 0.6-1.2 fps and depths of 2.0 and 4.8 feet were assumed. Based on these values, the O'Connor-Dobbins relationship is the clear choice for reaeration in the Holston.

Table E-4 presents a summary of reaeration coefficients that could be computed for the Holston using the most common prediction equations. Also, computations using a slightly

different approach, that of Tsivoglou, are tabulated. As can be seen, the reaeration rates computed by the O'Connor-Dobbins equation generally lie between the values predicted by the Churchill et al. (1962) and Owens et al. (1964) equations (Table E-4). The values predicted by Churchill et al.'s equation and the Laughbein-Durum (1967) equation are approximately equal.

A prediction technique not included in the version of QUAL-II used is Tsivoglou's (1976) approach. This method uses the change in head (elevation) and time of flow in a stream reach to predict reaeration. The general form of the equation is:

$$K_2 = C \cdot \Delta h \cdot t_f^{-1}$$

where K_2 is the reaeration coefficient, C is an escape coefficient, Δh is the change in elevation and t_f is the time of flow in a stream segment. The change in head in each model reach was scaled from USGS topographic maps and time of flow was measured during the field study. Tsivoglou recommends

that a value of C of 0.054 be used for flows in the range of 25 to 3000 cfs in stream segments that are moderately polluted and reasonably well mixed. He recommends that C be adjusted downwards to a limiting value of 0.030/ft for relatively large streams, but also states that the presence of prolific growths of aquatic weeds in the channel may enhance mixing and lead to somewhat higher magnitudes for C. Therefore, Tsivoglou's predictions with C values of 0.030/ft and 0.054/ft are presented in Table E-4.

It is difficult to select an appropriate C value for the Holston River without a measurement, but it would seem that a value of 0.054/ft would be consistent with the other prediction equations as this value gives the best fit to all the observed data. Thus, Tsivoglou's equation predictions with C = 0.054/ft might be regarded as a "best estimate" of K_2 with predictions with C = 0.030/ft giving a lower limiting value.

It is interesting to compare the predictions using the two approaches which, it would seem, given independent "best estimates" of reaeration in the Holston. These predictions

are compared graphically in Figure E-7. Both equations are reasonably close, with 30% of one another above HRM 121.4. However, from HRM 121.6 to HRM 118, the Tsivoglou equation predicts a reaeration coefficient over twice the O'Connor-Dobbins prediction. This difference would tend to indicate an error in one of the prediction equations, specifically in either the depth estimate or elevation change estimate for that segment of river. As the estimate of elevation change is a more straight-forward measurement than average depth, the latter is the most suspect figure. As will be seen later, the Tsivoglou equation predicts dissolved oxygen better in the lower reaches of the Holston.

Because of the uncertainty in the prediction of the reaeration coefficient, the model was run with predictions from both O'Connor-Dobbins equation and Tsivoglou's. Results are discussed under simulation results.

OTHER COEFFICIENTS--BENTHOS SOURCE RATES FOR BOD

The benthos source rate for BOD in QUAL-II was used to simulate plant respiration in the Holston. Respiration simulated alone, without accompanying oxygen production through

photosynthesis, will give an estimate of the oxygen levels the stream might approach in the early morning hours. Benthic oxygen demand was estimated by using the average respiration rate, 6.87 g/m^2/day at 20°C, measured during the biological survey. The rate was adjusted to 26.7°C using the relationship:

$$\text{Rate at } 20°C = \text{Rate at } T°C \times (1.065)^{T-20}$$

QUAL-II requires that the respiration rate be multiplied by the width of the stream for input. The resulting quantity was then multiplied by the percent plant coverage in the reach to give the estimated benthic demand. This calculation, with appropriate unit conversions and results are given in Table E-5.

OTHER MODEL INPUTS

The model input blocks from Data Type 7 through Data Type 9 only contain one quantity significant to this simulation. The temperature input in the initial conditions block is used as the stream temperature for steady state simulations or

if temperature is not simulated. The simulation was run at 26.7°C. Table E-7 shows that, except for the upper part of the South Fork Holston, stream temperatures average 25 - 27°C. Because the survey was done under low flow conditions, it was assumed that any incremental inflows were insignificant.

HEADWATER SOURCES

Two headwater sources, the South and North Forks of the Holston River, were simulated. The South Fork was assumed to have a flow of 750 cfs, a dissolved oxygen content of 6.2 mg/L (about 80% of saturation), and an ultimate BOD of 2.0 mg/L.

This BOD level is not consistent with study measurements (See Table E-7), but it is unclear how to interpret the measurements as no reason for the high survey values is evident. South Fork nutrient concentrations of 0.01 mg/L NH_3, 0.60 mg/L NO_3, and 0.04 mg/L P were input to the model. These levels are consistent with the average of the measurements.

The North Fork flow rate was input as 86 cfs, equal to a flow measurement made on the day of the dye study. The dissolved oxygen of this headwater was assumed to be 6.9 mg/L (about 90% of saturation) and the ultimate BOD of the source was assumed to be 2.0 mg/L. Nutrient concentrations of 0.6 mg/L NH_3, 0.10 mg/L NO_3, and 0.03 mg/L P were assumed.

As no attempt to simulate temperature was made, the headwater sources were input at a temperature of 26.7°C (80°F). The initial dissolved oxygen concentrations were selected to be compatible with this temperature. Table E-7 shows that the temperature in the upper reaches of the South Fork Holston River were about 18°C and dissolved oxygen averaged 7.1 mg/L, about 80% of the saturation value at that temperature.

WASTE LOADINGS

The waste loadings input to the model are given in Table E-6. The loadings were computed as flow-weighted means from the waste survey conducted on 19 to 23 July, just before the stream survey. Unfortunately, it was not possible to sample the discharges during the water quality survey. Therefore, it must be assumed that the discharges did not change

significantly. The deoxygenation coefficients (K_1) were estimated from long-term BODs (both with and without nitrification suppression) run as part of the waste survey. The Mead Paper Company and Kingsport STP discharges were input to the model as a single discharge.

Three withdrawals are included in waste loadings input block. A withdrawal of 100 cfs was "input" at SFHRM 5.6 to account for the water use by TEC, HAAP-Area A, Mead Paper Company, and the City of Kingsport plus consumptive uses in the area. Note that a withdrawal and discharge of cooling water by TEC is not formally "input" to the model. It was assumed that this discharge only takes in water and heats it to 26.7°C as no measurement was made on the discharge during the survey. Withdrawals are also included for HAAP-Area B and Holliston Mills.

RESULTS

The results of simulations with the QUAL-II water quality model are presented in Figures E-8 through E-13. The water quality survey results are presented in Table 7. A complete listing of a simulation run, giving all input values, is included at the end of the report.

Predicted and observed dissolved oxygen levels are shown in FiguresE-8 and E-9. Time of the observations are noted to the right of the data point. The wide range of observed dissolved oxygen levels is due to photosynthetic oxygen production from the aquatic plant community in the river. The dissolved oxygen curves labeled "BOD, Nitrogen, & Benthic Demand" would be expected to predict average early morning levels, or levels expected during a sequence of cloudy days when photosynthesis is at a minimum. The predicted curves should be adjusted down approximately 0.4 mg/L because of the effect of altitude (local barometric pressure) on the saturation concentration for dissolved oxygen. This factor is not included in the saturation expression in the model.

Figure E-8 gives predictions using Tsivoglou's reaeration formulation while Figure E-9 shows results using the O'Connor-Dobbins equation. Results are similar in the upper reaches of the river but, as expected from the predicted reaeration rates, diverge considerably below HRM 130. The two predictions are presented for comparison purposes only; the Tsivoglou reaeration estimate probably gives a better prediction.

The dissolved oxygen profiles show the effect of removing the benthic demand component and the nitrogen component from the model. This exercise indicates that the direct effect of ammonia nitrogen oxidation on the oxygen balance is very small. The effect of BOD from discharges and aquatic plant respiration are roughly equal, with BOD more important in the upper part of the model and respiration having a proportionately larger effect in the lower reaches.

The QUAL-II model predicts the "ultimate" carbonaceous BOD (Figure E-10) and the five-day BOD values must be estimated from the rate coefficients computed from the long-term BOD_5 run during the water quality survey (Table E-7). Most of the stream rate coefficients were on the order of 0.12/day to 0.15/day, so the five-day BOD would be about 1/2 of the ultimate BOD. The observed values are all five-day BOD.

Observed and predicted ammonia nitrogen concentrations are compared in Figure E-11. The predicted profile is actually based on Total Kjeldahl Nitrogen (TKN) discharges. The TKN concentrations give a better subjective "fit" to the observed

data and are used because the version of QUAL-II used does not include a compartment for the conversion of organic nitrogen to ammonia nitrogen. In any case, the impact of nitrogen oxidation on dissolved oxygen is not great, so this gives a "worst case" estimate. The results of the nitrogen oxidation process (Figure E-12) show that the predicted levels of nitrite + nitrate (NO_2 + NO_3) are somewhat greater than observed levels. Assuming the model mass balance and oxidation rates are correct, an unexplained mechanism for loss of nitrate from the system is indicated.

Phosphorus is modeled as a conservative substance (Figure E-13), i.e., in the model no phsophorus is lost from the system through settling or other mechanisms. Only the mass balance on phosphorus from discharges is computed. As the predicted levels exceed the osberved, phosphorus loss through some mechanism such as settling or plant uptake is indicated.

SUMMARY AND CONCLUSIONS

The results of this investigation indicate that the Holston River above HRM 118 is in reasonably clean condition, especially considering its condition as recently as 1969.

The simulations indicate that dissolved oxygen levels slightly below a 5 mg/L can be expected under conditions of low photosynthetic oxygen production and present discharges. Approximately half of the dissolved oxygen deficit under these conditions can be attributed to rooted aquatic plants.

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TABLE E-1

COMPUTATION OF COEFFICIENT FOR VELOCITY VS. FLOW EQUATION

Model reach	Average flow, cfs	Average velocity, fps	Coefficients	
			a	b
I	730.0	0.65*	0.674	0.0076
II	696.0	0.65*	0.674	0.0079
III	721.5	0.65	0.674	0.0077
IV	86.0	1.00	0.674	0.0497
V	807.5	0.65	0.674	0.0071
VI	783.3	1.11	0.674	0.0124
VII	802.3	0.63	0.674	0.0069
VIII	802.3	1.22	0.674	0.0135
IX	802.3	1.22	0.674	0.0135
X	802.3	1.01	0.539	0.0111
XI	802.3	0.66	0.539	0.0180
XII	802.3	0.78	0.539	0.0212
XIII	802.3	0.78	0.539	0.0212
XIV	802.3	0.89	0.539	0.0212

*Assumed velocity

TABLE E-2

HOLSTON RIVER. EPA SURVEY MEASUREMENTS

River mile	EPA survey measurements			
	Date	Flow	Depth	Width
141.3	7/20/77	1181	2.78	471
139.2	7/23/77	764	2.20	570
136.2	7/22/77	778	5.57	385
131.7	7/20/77	1096	1.65	460
128.5	7/20/77	1074	1.96	390
126.6	7/22/77	988	1.49	450
120.1	7/21/77	1334	1.34	670
121.6	7/24/77	2278	5.06	450
118.4	7/--/77	898	6.80	360
141.2	6/--/69	-	2.1	500
137.8	6/--/69	-	2.1	340
135.4	6/--/69	-	2.2	400
135.4	7/--/69	-	2.4	400
131.4	6/--/69	-	3.5	500
129.7	6/--/69	-	5.8	340
128.3	6/--/69	-	6.1	500
128.3	7/--/69	-	6.2	500
124.2	6/--/69	-	6.1	340
122.8	6/--/69	-	4.8	425
120.4	6/--/69	-	4.4	450
118.4	6/--/69	-	8.6	360

TABLE E-3

ASSUMED DEPTH FROM PREVIOUS MODELS

TVA model		Krenkel & Novotny model	
River mile	Depth, ft	River mile	Depth, ft
HRM141.2-SFHR1.2	3.2	SFHR3.5-SFHR5.6	3.0
HRM137.9-HRM141.2	5.2	SFHR2.5-SFHR3.5	2.5
HRM134.2-HRM137.9	4.5	HRM142.5-SFHR2.5	3.0
HRM131.5-HRM134.2	3.4	HRM140.7-HRM142.5	1.9
HRM128.3-HRM131.5	4.3	HRM137.9-HRM140.7	2.4
HRM124.3-HRM128.3	4.9	HRM135.4-HRM137.9	2.4
HRM118.4-HRM124.3	4.8	HRM131.5-HRM135.4	2.3
		HRM128.9-HRM131.5	6.1

TABLE E-4

River mile	Model reach	Velocity, cfs	Depth, ft	O'Connor-Dobbins[1]	Churchill et al.[2]	Owens et al[3]	Langbein Durum[4]	Energy Gradient	Tsivoglou[5] C=.030	Tsivoglou[5] C=.054
SF 8.0										
SF 5.0	I	0.65	2.6	2.5	1.5	2.8	1.4	-	-	-
SF 1.2	II	0.65	2.6	2.5	1.5	2.8	1.4	-	-	-
HR 142.2	III	0.65	2.6	2.5	1.5	2.8	1.4	1.36	1.0	1.8
HR 141.2	V	0.65	2.6	2.5	1.5	2.8	1.4	2.18	1.0	1.8
HR 139.2	VI	1.10	2.6	3.2	2.6	4.0	2.4	1.91	1.6	2.9
HR 136.2	VII	0.63	2.6	2.4	1.5	2.7	1.3	1.88	1.4	2.5
HR 133.2	VIII	1.22	2.6	3.4	2.8	4.2	2.6	1.88	1.4	2.5
HR 121.6	IX	1.22	2.6	3.4	2.8	4.2	2.6	1.88	1.4	2.5
HR 128.6	X	1.00	4.8	1.2	0.8	1.2	0.9	1.44	1.0	1.8
HR 126.8	XI	0.66	4.8	1.0	0.6	0.9	0.6	0.82	0.6	1.1
HR 124.0	XII	0.78	4.8	1.1	0.6	1.0	0.7	1.25	0.9	1.6
HR 121.6	XIII	0.78	4.8	1.1	0.6	1.0	0.7	1.25	0.9	1.6
HR 118.0	XIV	0.89	4.8	1.2	0.7	1.1	0.8	1.96	1.4	2.5

[1] O'Connor-Dobbins $K_2 = 12{\cdot}96 \cdot V^{0.5} \cdot D^{-1.5}$

[2] Churchill $K = 11.6\ V^{0.969} \cdot D^{-1.673}$

[3] Owens et al. $K = 21.7\ V^{0.67} \cdot D^{-1.85}$

[4] Langbein-Durum $K = 7.6\ V^{1.0} \cdot D^{-1.33}$

[5] Tsivoglou $K = C \cdot \Delta H \cdot t_f^{-1}$

TABLE E-5

CALCULATION OF BENTHIC DEMAND
HOLSTON RIVER. JULY 1977

Stream Reach	Width, Meters	% Plant Coverage	Benthic Demand mg lft -day
South Fork Holston River	94	35%	103,800
North Fork Holston River	94	20%	59,310
Holston RM 142.2 - 126.6	136	24%	103,000
Holston RM 126.6 - 118	136	31%	133,000

Note: Computation as follows:

Respiration = $6.87\ g/m^2$ - day at 20^0 C
= $10.35\ g/m^2$ - day at 26.7^0C

Benthos Source Rate, $\frac{mg}{ft\text{-}day}$ =

$$\frac{\%\ Coverage}{100} \times \text{Width, m} \times \frac{10.35g}{m^2\text{-day}} \times \frac{.304m}{ft} \times \frac{1{,}000mg}{g}$$

TABLE E-6
JULY 19-23, 1977

Flow-Weighted Means

Discharger	Flow MGD (CFS)	K_1 Day^{-1}	BOD_5 (BOD_u) mg/L	Temp °C (^0F)	DO mg/L	TKN mg/L	NH_3N mg/L	NO_2 NO_3-N mg/L	Total P mg/L
Tennessee Eastman Co.	16.90 (26.10)	0.10	15.0 (38.0)	26.0 (79.0)	6.4	8.40	4.70	0.06	3.84
Holston Army Ammunition Plant Area A	8.40 (13.00)	0.10	5.4 (13.6)	22.0 (72.0)	6.5	7.20	6.10	0.60	0.37
Holston Army Ammunition Plant Area B Discharges HB005P & HB005W	14.70 (22.70)	0.10	14.1 (35.2)	27.0 (80.0)	7.0	0.70	0.33	0.62	0.18
Holston Army Annunition Plant Area B Discharges HB006 & HB008	32.00 (49.50)	0.10	9.1 (22.7)	27.0 (80.0)	7.0	0.60	0.32	2.13	0.13
Holliston Mills	0.45 (00.70)	0.23	327 (478)	31.0 (88.0)	----	8.10	1.38	0.01	3.54
Mead Paper Corp.	11.60 (17.90)	0.10	39 (100)	32.0 (89.0)	----	4.10	0.36	0.01	0.66
Kingsport STP	6.77 (10.50)	0.16	27.6 (50)	26.0 (78.0)	4.0	10.00	8.30	0.49	6.10
Mead & Kingsport Combined	----- (28.40)	----	---- 81.5	35.8 (85.0)	4.0	6.30	3.30	0.19	2.70

TABLE E-7

Summary of Water Quality Survey Results
HOLSTON RIVER. JULY, 1977

		D.O. mg/L	BOD mg/L	TKN mg/L	NH_3-N mg/L	NO_2+NO_3-N mg/L	Total P mg/L	Temperature °C
NFHRM 0.6	7/23 0640	6.2	2.2	0.27	---	---	.04	---
	7/23 1210	7.1	1.2	0.23	.01	.12	.03	27
	7/23 1900	8.8	1.4*	0.30	.01	.08	.02	29
Mean			1.6	0.27	.06	.10	.03	28
SFHRM 5.6	7/23 0715	6.9	2.1*	0.20	.01	.58	.04	16
	7/23 1245	7.2	6.4	----	.05	.61	.06	21
	7/23 1800	8.0	1.7*	0.10	.01	.59	.02	21
	7/23 0610	6.3	3.5	0.12	.05	.59	.05	15
Mean		7.1	3.2	0.14	.03	.59	.04	18
SFHRM 1.2	7/23 0620	3.4	1.0*	0.94	.83	.54	.14	23
	7/23 1220	7.1	3.2	0.82	.68	.54	.17	26
	7/23 1830	7.8	2.2*	1.08	.83	.55	.20	28
	7/24 0630	4.8	1.8	0.76	.33	.53	.24	23
Mean			2.0	0.90	.67	.54	.19	25
HRM 141.3	7/23 1100	4.5	2.7*	1.10	.83	.55	.17	24
	7/23 1700	---	2.3	1.08	.75	.59	.18	27
	7/23 2230	---	1.8*	0.96	.90	.54	.24	27
	7/23 1040	5.2	2.2	0.65	.42	.50	.24	24
Mean			2.2	0.95	.73	.55	.21	25.5
HRM 139.2	7/23 1345	5.6	1.4*	0.57	.75	.42	.11	25
	7/23 1940	8.4	2.0	0.84	.50	.40	.12	28
	7/24 0210	5.4	2.2	0.53	.43	.32	.16	28
	7/24 1400	8.1	1.6	0.40	.20	.27	.10	26
Mean			1.8	0.59	.47	.35	.12	26.7
HRM 136.2	7/23 2100	7.2	1.2*	----	---	---	---	27.5
	7/24 0300	4.8	2.0	----	---	---	---	28.0
	7/24 0915	3.9	2.1	1.26	.52	.51	.70	25.0
Mean			1.8			.51		26.8
HRM 131.7	7/24 0335	4.3	2.1	0.72	.40	.74	.11	25
	7/24 0900	4.6	2.3	0.70	.55	.72	.11	25.5
	7/24 1500	9.5	1.7	0.50	.23	.62	.19	27
Mean			2.0	0.64	.39	.69	.14	25.8
HRM 128.5	7/24 0845	5.1	2.0	0.65	.38	.72	.10	25
	7/24 1445	7.4	1.8	0.65	.32	.70	.19	27
	7/24 2045	7.5	2.0	0.57	.27	.68	.18	27
Mean			1.9	0.62	.32	.70	.16	26.3
HRM 126.6	7/24 1300	6.6	1.7	0.62	.32	.77	.10	27
	7/24 1930	8.0	1.7	0.70	.30	.75	.12	27.5
	7/24 2245	5.1	1.4	0.57	.30	.80	.11	26.5
Mean			1.6	0.63	.31	.77	.11	27.0
HRM 118.5	7/25 0350	4.9	2.5	----	---	---	---	----

TABLE E-8

WATER RESOURCES ENGINEERS, INC. - SPRINGFIELD, VA.

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* * * DATA LIST FOR MODIFIED QUAL1 STREAM QUALITY ROUTING MODEL * * *

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-I PROGRAM TITLES
TITLE01		TWDB/WRE EXPANDED VERSION OF QUAL-I
TITLE02		NAME OF BASIN =HOLSTON
TITLE03	NO	CONSERVATIVE MINERAL I IN MG/L
TITLE04	NO	CONSERVATIVE MINERAL II IN MG/L
TITLE05	NO	CONSERVATIVE MINERAL III IN MG/L
TITLE06	NO	TEMPERATURE IN DEGREES FAHRENHEIT
TITLE07	YES	BIOCHEMICAL OXYGEN DEMAND IN MG/L
TITLE08	NO	ALGAE AS CHL.A IN UG/L
TITLE09	YES	PHOSPHOROUS AS P IN MG/L
TITLE10	YES	AMMONIA AS N MG/L
TITLE11		NITRITE AS N MG/L
TITLE12		NITRATE AS N MG/L
TITLE13	YES	DISSOLVED OXYGEN IN MG/L
TITLE14	NO	COLIFORMS AS MPN
TITLE15	NO	RADIONUCLIDE (NOT PROGRAMMED)

ENDTITLE

$$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE		CARD TYPE	
LIST DATA INPUT	0.0		0.0
WRITE FINAL SUMMARY	0.0		0.0
NO FLOW AUGMENTATION	0.0		0.0
STEADY STATE	0.0		0.0
NUMBER OF REACHES =	14.00000	NUMBER OF JUNCTIONS =	1.00000
NUM OF HEADWATERS =	2.00000	NUMBER OF WASTE LOADS =	9.00000
TIME STEP (HOURS) =	0.0	LNTH. COMP. ELEMENT (MI) =	0.20000
MAXIMUM ROUTE TIME (HRS) =	30.00000	TIME INC. FOR RPT2 (HRS) =	0.0
ENDATA1	0.0		0.0

$$$DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS)$$$

CARD TYPE		CARD TYPE	
O UPTAKE BY NH3 OXID(MG O/MG N) =	3.2200	O UPTAKE BY NO2 OXID(MG O/MG/N) =	1.1200
O PROD. BY ALGAE (MG O/MG A) =	1.6000	O UPTAKE BY ALGAE (MG O/MG A) =	2.0000
N CONTENT OF ALGAE (MG N/MG A) =	0.0800	P CONTENT OF ALGAE (MG P/MG A) =	0.0120
ALG MAX SPEC GROWTH RATE(1/DAY) =	1.0000	ALGAE RESPIRATION RATE (1/DAY) =	0.2000
N HALF SATURATION CONST. (MG/L) =	0.3000	P HALF SATURATION CONST. (MG/L) =	0.0400
LIGHT HALF SAT CONST(LNGLY/MIN) =	0.0300	TOTAL DAILY RADIATION(LANGLEYS) =	400.0000
ENDATA1A	0.0		0.0

$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE		REACH ORDER AND IDENT		R. MILE		R. MILE
STREAM REACH	1.	RCH=S. FORK HOLSTON	FROM	5.0	TO	8.0
STREAM REACH	2.	RCH=S. FORK HOLSTON	FROM	1.2	TO	5.0
STREAM REACH	3.	RCH=S. FORK HOLSTON	FROM	0.0	TO	1.2
STREAM REACH	4.	RCH=N. FORK HOLSTON	FROM	0.0	TO	1.0
STREAM REACH	5.	RCH=HOLSTON RIVER	FROM	141.2	TO	142.2
STREAM REACH	6.	RCH=HOLSTON RIVER	FROM	139.2	TO	141.2
STREAM REACH	7.	RCH=HOLSTON RIVER	FROM	136.2	TO	139.2
STREAM REACH	8.	RCH=HOLSTON RIVER	FROM	133.0	TO	136.2
STREAM REACH	9.	RCH=HOLSTON RIVER	FROM	131.6	TO	133.0
STREAM REACH	10.	RCH=HOLSTON RIVER	FROM	128.5	TO	131.6

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STREAM REACH	11.	RCH=HOLSTON RIVER	FROM	129.6	TO	128.5
STREAM REACH	12.	RCH=HOLSTON RIVER	FROM	124.0	TO	126.6
STREAM REACH	13.	RCH=HOLSTON RIVER	FROM	121.6	TO	124.0
STREAM REACH	14.	RCH=HOLSTON RIVER	FROM	118.0	TO	121.6
ENDATA2	0.			0.0		0.0

$$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE	REACH	AVAIL HOWS	TARGET	ORDER OF AVAIL SOURCES					
ENDATA3	0.	0.	0.0	0.	0.	0.	0.	0.	0.

$$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE	REACH	ELEMENTS/REACH	COMPUTATIONAL FLAGS
FLAG FIELD	1.	15.	1.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.
FLAG FIELD	2.	19.	2.2.6.2.6.2.2.2.2.2.2.2.2.6.2.2.2.2.2.2.0.
FLAG FIELD	3.	6.	2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	4.	5.	1.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	5.	5.	4.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	6.	10.	2.2.2.2.2.2.7.6.2.2.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	7.	15.	6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
FLAG FIELD	8.	15.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.
FLAG FIELD	9.	8.	2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	10.	16.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.7.0.0.0.0.
FLAG FIELD	11.	9.	6.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD	12.	13.	2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.
FLAG FIELD	13.	12.	2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.
FLAG FIELD	14.	18.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.
ENDATA4	0.	0.	0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

$$$ DATA TYPE 5 (HYDRAULIC COEFFICIENTS FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE	REACH	COEFQV	EXPOQV	COEFQH	EXPOQH	CMANN
HYDRAULICS	1.	0.008	0.674	2.600	0.001	0.018
HYDRAULICS	2.	0.008	0.674	2.600	0.001	0.018
HYDRAULICS	3.	0.008	0.674	2.600	0.001	0.018
HYDRAULICS	4.	0.050	0.674	2.000	0.001	0.018
HYDRAULICS	5.	0.007	0.674	2.600	0.001	0.018
HYDRAULICS	6.	0.012	0.674	2.600	0.001	0.018
HYDRAULICS	7.	0.007	0.674	2.600	0.001	0.018
HYDRAULICS	8.	0.014	0.674	2.600	0.001	0.018
HYDRAULICS	9.	0.014	0.674	2.600	0.001	0.018
HYDRAULICS	10.	0.011	0.674	4.800	0.001	0.018
HYDRAULICS	11.	0.018	0.539	4.800	0.001	0.018
HYDRAULICS	12.	0.021	0.539	4.800	0.001	0.018
HYDRAULICS	13.	0.021	0.539	4.800	0.001	0.018
HYDRAULICS	14.	0.024	0.539	4.800	0.001	0.018
ENDATA5	0.	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE	REACH	K1	K3	K2OPT	K2	COEFK2	EXPOK2
REACT COEF	1.	0.23	0.0	1.	1.80	0.0	0.0
REACT COEF	2.	0.76	0.0	1.	1.80	0.0	0.0
REACT COEF	3.	0.76	0.0	1.	1.80	0.0	0.0
REACT COEF	4.	0.23	0.0	1.	1.80	0.0	0.0
REACT COEF	5.	0.76	0.0	1.	1.80	0.0	0.0
REACT COEF	6.	0.76	0.0	1.	2.90	0.0	0.0
REACT COEF	7.	0.76	0.0	1.	2.50	0.0	0.0
REACT COEF	8.	0.30	0.0	1.	2.50	0.0	0.0
REACT COEF	9.	0.30	0.0	1.	2.50	0.0	0.0

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REACT COEF	10.	0.30	0.0	1.	1.80	0.0	0.0
REACT COEF	11.	0.30	0.0	1.	1.80	0.0	0.0
REACT COEF	12.	0.30	0.0	1.	1.80	0.0	0.0
REACT COEF	13.	0.30	0.0	1.	1.80	0.0	0.0
REACT COEF	14.	0.30	0.0	1.	2.50	0.0	0.0
ENDATA5	0.	0.0	0.0	0.	0.0	0.0	0.0

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$$$ DATA TYPE 6A (ALGAE, NITROGEN, AND PHOSPHORUOUS CONSTANTS) $$$

CARD TYPE	REACH	ALPHA0	ALGSET	CKNH3	CKNO2	SNH3	SPO4
ALGAE, N AND P COEF	1.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	2.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	3.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	4.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	5.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	6.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	7.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	8.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	9.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	10.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	11.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	12.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	13.	75.0	3.00	0.30	0.50	0.0	0.0
ALGAE, N AND P COEF	14.	75.0	3.00	0.30	0.50	0.0	0.0
ENDATA6A	0.	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 6B (OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	CK4	CK5	EXCOEF	CK6
OTHER COEFFICIENTS	1.	103800.00	1.00	0.60	0.0
OTHER COEFFICIENTS	2.	103800.00	1.00	0.60	0.0
OTHER COEFFICIENTS	3.	103800.00	1.00	0.60	0.0
OTHER COEFFICIENTS	4.	59310.00	1.00	0.60	0.0
OTHER COEFFICIENTS	5.	103000.00	1.00	0.60	0.0
OTHER COEFFICIENTS	6.	103000.00	1.00	0.60	0.0
OTHER COEFFICIENTS	7.	103000.00	1.00	0.60	0.0
OTHER COEFFICIENTS	8.	103000.00	1.00	0.60	0.0
OTHER COEFFICIENTS	9.	103000.00	1.00	0.60	0.0
OTHER COEFFICIENTS	10.	103000.00	1.00	0.60	0.0
OTHER COEFFICIENTS	11.	103000.00	1.00	0.60	0.0
OTHER COEFFICIENTS	12.	133000.00	1.00	0.60	0.0
OTHER COEFFICIENTS	13.	133000.00	1.00	0.60	0.0
OTHER COEFFICIENTS	14.	133000.00	1.00	0.60	0.0
ENDATA6B	0.	0.0	0.0	0.0	0.0

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
INITIAL CONDITIONS	1.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	2.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	3.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	4.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	5.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	6.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	7.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	8.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	9.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	10.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	11.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	12.	80.0	6.0	2.0	0.0	0.0	0.0
INITIAL CONDITIONS	13.	80.0	6.0	2.0	0.0	0.0	0.0

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INITIAL CONDITIONS	14.	80.0	6.0	2.0	0.0	0.0	0.0
ENDATA7	0.	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHLOROPHYLL A, NITROGEN, PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN
INITIAL COND-2	1.	1.0	0.80	0.01	0.60	0.20	0.0	0.0
INITIAL COND-2	2.	1.0	0.80	0.01	0.60	0.20	0.0	0.0
INITIAL COND-2	3.	1.0	0.80	0.01	0.60	0.20	0.0	0.0
INITIAL COND-2	4.	1.0	0.01	0.01	0.60	0.01	0.0	0.0
INITIAL COND-2	5.	1.0	0.80	0.01	0.60	0.20	0.0	0.0
INITIAL COND-2	6.	1.0	0.80	0.01	0.60	0.20	0.0	0.0
INITIAL COND-2	7.	1.0	0.80	0.01	0.60	0.20	0.0	0.0
INITIAL COND-2	8.	1.0	0.60	0.01	0.60	0.20	0.0	0.0
INITIAL COND-2	9.	1.0	0.60	0.01	0.60	0.10	0.0	0.0
INITIAL COND-2	10.	1.0	0.60	0.01	0.60	0.10	0.0	0.0
INITIAL COND-2	11.	1.0	0.60	0.01	0.60	0.10	0.0	0.0
INITIAL COND-2	12.	1.0	0.60	0.01	0.60	0.10	0.0	0.0
INITIAL COND-2	13.	1.0	0.60	0.01	0.60	0.10	0.0	0.0
INITIAL COND-2	14.	1.0	0.60	0.01	0.60	0.10	0.0	0.0
ENDATA7A	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 8 (RUNOFF CONDITIONS) $$$

CARD TYPE	REACH	Q	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
RUNOFF CONDITIONS	1.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	2.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	3.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	4.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	5.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	6.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	7.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	8.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	9.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	10.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	11.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	12.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	13.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
RUNOFF CONDITIONS	14.	0.0	80.0	6.0	2.0	0.0	0.0	0.0
ENDATA8	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 8A (INCREMENTAL FLOW CONDITIONS FOR NITROGEN, PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN
RUNOFF COND-2	1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	6.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	7.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	8.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	9.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNOFF COND-2	14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDATA8A	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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TABLE E-8

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$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT	UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1. JNC=N. & S. FORK	40.	46.	45.
ENDATA9	0.	0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWATER ORDER AND IDENT	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
HEADWATER	1. HWD=S. FORK HOLSTON	750.0	80.0	6.2	2.0	0.0	0.0	0.0
HEADWATER	2. HWD=N. FORK HOLSTON	86.0	80.0	6.9	2.0	0.0	0.0	0.0
ENDATA10	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL,NITROGEN, PHOSPHORUS, COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE	HDWATER	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN
HEADWATER-2	1.	15.0	0.03	0.01	0.60	0.04	0.0	0.0
HEADWATER-2	2.	15.0	0.06	0.01	0.10	0.03	0.0	0.0
ENDATA10A	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 11 (WASTE LOADINGS) $$$

CARD TYPE	WASTE LOAD ORDER AND IDENT	EFF	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
WASTELOAD	1. WSL=TEC WDRL	0.0	-100.00	80.0	7.0	2.0	0.0	0.0	0.0
WASTELOAD	2. WSL=TEC DISCHARGE	0.0	26.10	79.0	6.4	38.0	0.0	0.0	0.0
WASTELOAD	3. WSL=HAAP-A	0.0	13.00	72.0	6.5	13.6	0.0	0.0	0.0
WASTELOAD	4. WSL=MEAD+KINGSPORT	0.0	28.40	85.0	4.0	81.5	0.0	0.0	0.0
WASTELOAD	5. WSL=HAAP-B WDRL	0.0	-77.40	80.0	7.0	2.0	0.0	0.0	0.0
WASTELOAD	6. WSL=HAAP-B #1	0.0	22.70	80.0	7.0	35.2	0.0	0.0	0.0
WASTELOAD	7. WSL=HAAP-B #2	0.0	49.50	80.0	7.0	22.7	0.0	0.0	0.0
WASTELOAD	8. WSL=HOLLISTON WDRL	0.0	-0.70	80.0	7.0	2.0	0.0	0.0	0.0
WASTELOAD	9. WSL=HOLLISTON EFFL	0.0	0.70	88.0	0.0	478.0	0.0	0.0	0.0
ENDATA11	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 11A (WASTE LOAD CHARACTERISTICS - ALGAE,NITROGEN,PHOSPHORUS, COLIFORMS AND RADIONUCLIDES) $$$

CARD TYPE	WASTE LOAD ORDER AND IDENT	CHL. A	NH3	NO2	NO3	PO4	COLI	RADN
WASTELOAD-2	1. WSL=TEC WDRL	0.0	0.10	0.01	0.10	0.10	0.0	0.0
WASTELOAD-2	2. WSL=TEC DISCHARGE	0.0	8.41	0.01	0.06	3.64	0.0	0.0
WASTELOAD-2	3. WSL=HAAP-A	0.0	7.24	0.01	0.60	0.37	0.0	0.0
WASTELOAD-2	4. WSL=MEAD+KINGSPORT	0.0	6.30	0.01	0.19	2.70	0.0	0.0
WASTELOAD-2	5. WSL=HAAP-B WDRL	0.0	0.10	0.01	0.10	0.10	0.0	0.0
WASTELOAD-2	6. WSL=HAAP-B #1	0.0	0.70	0.01	0.62	0.13	0.0	0.0
WASTELOAD-2	7. WSL=HAAP-B #2	0.0	0.60	0.01	2.13	0.13	0.0	0.0
WASTELOAD-2	8. WSL=HOLLISTON WDRL	0.0	0.10	0.01	0.10	0.10	0.0	0.0
WASTELOAD-2	9. WSL=HOLLISTON EFFL	0.0	8.10	0.01	0.01	3.54	0.0	0.0
ENDATA11A		0.0	0.0	0.0	0.0	0.0	.0	

TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 1.0 RCH=S. FORK HOLSTON
RIVER MILES 5.0 TO 8.0

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	750.000	650.000	750.000	650.000	730.000
VELOCITY (FPS)	=	0.659	0.598	0.659	0.598	0.647
DEPTH (FT)	=	2.617	2.617	2.617	2.617	2.617

2. WATER QUALITY PARAMETER VALUES * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	6.19	6.18	6.18	6.17	6.16	6.16	6.15	6.14	6.14	6.13	6.13	6.12	6.12	6.11	6.10					
BOD	1.99	1.98	1.97	1.95	1.94	1.93	1.92	1.91	1.90	1.89	1.88	1.87	1.86	1.84	1.83					
NH3	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03					
NO2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01					
NO3	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60					
PO4	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04					

* NOTE* UNITS ARE MG/L* EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

KTBOD = 0.23
KNH3 = 0.30
KNO2 = 0.50
KCOLI = 1.00
KRON = 0.0

SETTLING RATES (1/DAY)

BOD = 0.0
ALGAE = 3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD =*****
NH3 = 0.0
PO4 = 0.0

REAERATION RATE (1/DAY)

K2 = 1.600

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 75.00

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TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 2.0 RCH=S. FORK HOLSTON
RIVER MILES 1.2 TO 5.0

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1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	650.000	717.500	717.500	650.000	692.582
VELOCITY (FPS)	=	0.622	0.664	0.664	0.622	0.649
DEPTH (FT)	=	2.617	2.617	2.617	2.617	2.617

2. WATER QUALITY PARAMETER VALUES * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	6.07	6.04	5.99	5.93	5.88	5.82	5.76	5.71	5.66	5.62	5.57	5.53	5.49	5.34	5.25	5.17	5.09	5.02	4.95	
BOD	1.79	1.76	3.10	3.04	3.17	3.11	3.05	3.00	2.94	2.88	2.83	2.77	2.72	5.73	5.62	5.52	5.42	5.31	5.22	
NH3	0.03	0.03	0.35	0.34	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.44	0.67	0.66	0.66	0.65	0.65	0.65	
NO2	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.07	
NO3	0.60	0.60	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.59	0.59	0.57	0.57	0.57	0.57	0.57	0.57	
PO4	0.04	0.04	0.14	0.14	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.29	0.29	0.29	0.29	0.29	0.29	

* NOTE* UNITS ARE MG/L, EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

KBOD = 0.76
KNH3 = 0.30
KNO2 = 0.50
KCOLI = 1.00
KRUN = 0.0

SETTLING RATES (1/DAY)

BOD = 0.0
ALGAE = 3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD =*****
NH3 = 0.0
PO4 = 0.0

REAERATION RATE (1/DAY)

K2 = 1.800

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 75.00

TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 3.0 RCH=S. FORK HOLSTON
RIVER MILES 0.0 TO 1.2

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	717.500	717.500	717.500	717.500	717.500
VELOCITY (FPS)	=	0.648	0.648	0.648	0.648	0.648
DEPTH (FT)	=	2.617	2.617	2.617	2.617	2.617

2. WATER QUALITY PARAMETER VALUES * * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.89	4.83	4.77	4.72	4.67	4.62														
BOD	5.12	5.02	4.92	4.83	4.74	4.65														
NH3	0.64	0.64	0.63	0.63	0.62	0.62														
NO2	0.07	0.08	0.08	0.08	0.09	0.09														
NO3	0.58	0.58	0.58	0.58	0.58	0.58														
PO4	0.29	0.29	0.29	0.29	0.29	0.29														

* NOTE* UNITS ARE MG/L* EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

K1(BOD	=	0.75
KNH3	=	0.30
KNO2	=	0.50
KCOLI	=	1.00
KBOD	=	0.0

SETTLING RATES (1/DAY)

BOD	=	0.0
ALGAE	=	3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD	=	*****
NH3	=	0.0
PO4	=	0.0

REAERATION RATE (1/DAY)

K2	=	1.800

CHLOR A/ALGAE RATIO (UG/MG)

RATIO	=	75.00

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TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 5.0 RCH=HOUSTON RIVER
RIVER MILES 141.2 TO 142.2

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1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	803.500	803.500	803.500	803.500	803.500
VELOCITY (FPS)	=	0.644	0.644	0.644	0.644	0.644
DEPTH (FT)	=	2.617	2.617	2.617	2.617	2.617

2. WATER QUALITY PARAMETER VALUES * * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.69	4.66	4.64	4.61	4.59															
BOD	4.27	4.19	4.11	4.03	3.95															
NH3	0.55	0.55	0.54	0.54	0.53															
NO2	0.09	0.09	0.09	0.09	0.10															
NO3	0.53	0.53	0.53	0.53	0.53															
PO4	0.25	0.26	0.26	0.26	0.26															

* NOTE* UNITS ARE MG/L, EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

KTBOD	=	0.76
KNH3	=	0.30
KNO2	=	0.50
KCOLI	=	1.00
KBEN	=	0.0

SETTLING RATES (1/DAY)

BOD	=	0.0
ALGAE	=	3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD	=*****
NH3	= 0.0
PO4	= 0.0

REAERATION RATE (1/DAY)

K2 = 1.800

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 75.00

TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 5.0 RCH=HOLSTON RIVER
RIVER MILES 139.2 TO 141.2

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	803.500	748.800	803.500	726.100	779.349
VELOCITY (FPS)	=	1.126	1.073	1.126	1.051	1.103
DEPTH (FT)	=	2.617	2.617	2.617	2.617	2.617

2. WATER QUALITY PARAMETER VALUES * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.59	4.60	4.61	4.62	4.63	4.64	4.65	4.72	4.71	4.71										
BOD	3.89	3.85	3.81	3.76	3.72	3.68	3.64	4.54	4.49	4.44										
NH3	0.53	0.53	0.53	0.52	0.52	0.52	0.52	0.52	0.52	0.52										
NO2	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11										
NO3	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54										
PO4	0.25	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26										

* NOTE* UNITS ARE MG/L, EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

K1BOD	=	0.76
K1NH3	=	0.30
K1NO2	=	0.50
KCOLI	=	1.00
KBOD	=	0.0

SETTLING RATES (1/DAY)

BOD	=	0.0
ALGAE	=	3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD	= 0 0 0 0 0
NH3	= 0.0
PO4	= 0.0

REAERATION RATE (1/DAY)

K2 = 2.900

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 75.00

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TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 4.0 RCH=N. FORK HOLSTON
RIVER MILES 0.0 TO 1.0

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	86.000	86.000	86.000	86.000	86.000
VELOCITY (FPS)	=	1.000	1.000	1.000	1.000	1.000
DEPTH (FT)	=	2.009	2.009	2.009	2.009	2.009

2. WATER QUALITY PARAMETER VALUES * * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	6.63	6.36	6.09	5.84	5.59															
BOD	1.99	1.98	1.98	1.97	1.96															
NH3	0.06	0.06	0.06	0.06	0.06															
NO2	0.01	0.01	0.01	0.01	0.01															
NO3	0.10	0.10	0.10	0.10	0.10															
PO4	0.03	0.03	0.03	0.03	0.03															

* NOTE* UNITS ARE MG/L* EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

K1BOD = 0.23
KNH3 = 0.30
KNO2 = 0.50
KCOLI = 1.00
KRDN = 0.0

SETTLING RATES (1/DAY)

BOD = 0.0
ALGAE = 3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD =*****
NH3 = 0.0
PO4 = 0.0

REAERATION RATE (1/DAY)

K2 = 1.800

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 79.00

TABLE E-8

FINAL REPORT

REACH NO. 7.0 RCH=HOLSTON RIVER
RIVER MILES 136.2 TO 134.2

1. HYDRAULIC PARAMETER VALUES

PARAMETER	HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	798.300	798.300	798.300	798.300	798.300
VELOCITY (FPS)	0.624	0.624	0.624	0.624	0.624
DEPTH (FT)	2.617	2.617	2.617	2.617	2.617

2. WATER QUALITY PARAMETER VALUES

ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.84	4.83	4.82	4.81	4.81	4.81	4.81	4.81	4.81	4.82	4.83	4.84	4.85	4.86	4.87					
BOD	5.49	5.38	5.27	5.16	5.06	4.96	4.86	4.77	4.67	4.58	4.49	4.40	4.31	4.23	4.14					
NH3	0.52	0.51	0.51	0.50	0.50	0.50	0.49	0.49	0.49	0.48	0.48	0.47	0.47	0.47	0.46					
NO2	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.14	0.14					
PO4	0.64	0.65	0.65	0.65	0.65	0.65	0.65	0.66	0.66	0.66	0.66	0.66	0.66	0.67	0.67					
	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25					

NOTE: UNITS ARE MG/L, EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS

DECAY RATES (1/DAY)

KBOD	= 0.76
KNH3	= 0.30
KNO2	= 0.50
KCOLI	= 1.00
KPOI	= 0.0

SETTLING RATES (1/DAY)

BOD	= 0.0
ALGAE	= 3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD	=*****
NH3	= 0.0
PO4	= 0.0

REAERATION RATE (1/DAY)

K2 = 2.500

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 75.00

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TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 8.0 ROANOKE RIVER
RIVER MILES 133.0 TO 130.2

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	798.300	798.300	798.300	798.300	798.300
VELOCITY (FPS)	=	1.220	1.220	1.220	1.220	1.220
DEPTH (FT)	=	2.617	2.617	2.617	2.617	2.617

2. WATER QUALITY PARAMETER VALUES * * * * * *

ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.90	4.91	4.91	4.92	4.92	4.92	4.93	4.93	4.94	4.94	4.94	4.95	4.95	4.95	4.96					
BOD	4.12	4.10	4.09	4.07	4.05	4.04	4.02	4.00	3.99	3.97	3.95	3.94	3.92	3.91	3.89					
NH3	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44	0.44	0.44					
NO2	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15					
NO3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68					
PO4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25					

* NOTE* UNITS ARE MG/L* EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)	REAERATION RATE (1/DAY)	CHLOR A/ALGAE RATIO (UG/MG)
K1BOD =	0.30	BOD =	0.0	BOD =*****	K2 = 2.500	RATIO = 75.00
KNH3 =	0.30	ALGAE =	3.00	NH3 = 0.0		
KNO2 =	0.50			PO4 = 0.0		
KCOLI =	1.00					
KBON =	0.0					

TABLE E-8

FINAL REPORT

REACH NO. 9.0 ROANOKE RIVER
RIVER MILES 131.6 TO 133.0

1. HYDRAULIC PARAMETER VALUES

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	798.300	798.300	798.300	798.300	798.299
VELOCITY (FPS)	=	1.220	1.220	1.220	1.220	1.220
DEPTH (FT)	=	2.617	2.617	2.617	2.617	2.617

2. WATER QUALITY PARAMETER VALUES

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.96	4.97	4.97	4.97	4.98	4.98	4.98	4.99												
BOD	3.88	3.86	3.84	3.83	3.81	3.80	3.78	3.77												
NH3	0.43	0.43	0.43	0.43	0.43	0.42	0.42	0.42												
NO2	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.16												
NO3	0.58	0.68	0.69	0.69	0.69	0.69	0.69	0.69												
PO4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25												

* NOTE* UNITS ARE MG/L. EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS

DECAY RATES (1/DAY)

KBOD	=	0.30
KNH3	=	0.30
KNO2	=	0.50
KCOLI	=	1.00
KPO4	=	0.0

SETTLING RATES (1/DAY)

BOD	=	0.0
ALGAE	=	3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD	= 0.0
NH3	= 0.0
PO4	= 0.0

REAERATION RATE (1/DAY)

K2 = 2.500

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 75.00

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TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 10.0 RCH-HOUSTON RIVER
RIVER MILES 128.5 TO 131.6

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	798.300	797.599	798.300	797.599	798.254
VELOCITY (FPS)	=	1.003	1.003	1.003	1.003	1.003
DEPTH (FT)	=	4.832	4.832	4.832	4.832	4.832

2. WATER QUALITY PARAMETER VALUES * * * * * * *

ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.97	4.97	4.96	4.95	4.94	4.94	4.93	4.92	4.91	4.90	4.89	4.89	4.88	4.87	4.87	4.86				
BOD	3.75	3.73	3.71	3.69	3.68	3.66	3.64	3.62	3.60	3.59	3.57	3.55	3.53	3.52	3.50	3.48				
NH3	0.42	0.42	0.42	0.41	0.41	0.41	0.41	0.40	0.40	0.40	0.40	0.40	0.40	0.39	0.39	0.39				
NO2	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17				
NO3	0.69	0.69	0.69	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.71	0.71	0.71	0.71	0.71	0.71				
PO4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25				

* NOTE* UNITS ARE MG/L, EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

K1BOD = 0.30
KNH3 = 0.30
KNO2 = 0.50
KCOLI = 1.00
KRDN = 0.0

SETTLING RATES (1/DAY)

BOD = 0.0
ALGAE = 3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD =*****
NH3 = 0.0
PO4 = 0.0

REAERATION RATE (1/DAY)

K2 = 1.800

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 75.0

TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 11.0 RCH=HOLSTON RIVER
RIVER MILES 126.6 TO 128.5

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	798.299	798.299	798.299	798.299	798.298
VELOCITY (FPS)	=	0.660	0.660	0.660	0.660	0.660
DEPTH (FT)	=	4.832	4.832	4.832	4.832	4.832

2. WATER QUALITY PARAMETER VALUES * * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.85	4.86	4.86	4.87	4.87	4.88	4.88	4.89	4.89											
BOD	3.87	3.84	3.81	3.79	3.76	3.73	3.70	3.67	3.65											
NH3	0.39	0.39	0.39	0.38	0.38	0.38	0.38	0.37	0.37											
NO2	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17											
NO3	0.71	0.72	0.72	0.72	0.72	0.72	0.73	0.73	0.73											
PO4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25											

* NOTE* UNITS ARE MG/L* EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

K1=OD	=	0.30
KN=3	=	0.30
K1O2	=	0.50
*COLI	=	1.00
**K3(	=	0.0

SETTLING RATES (1/DAY)

BOD	=	0.0
ALGAE	=	3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD =*****
NH3 = 0.0
PO4 = 0.0

REAERATION RATE (1/DAY)

K2 = 1.500

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 79.00

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TABLE E-8

* * * * * * FINAL REPORT * * * * * *

REACH NO. 12.0 ROCHELOSTON RIVER
RIVER MILES 124.0 TO 126.6

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	798.299	798.299	798.299	798.299	798.298
VELOCITY (FPS)	=	0.777	0.777	0.777	0.777	0.777
DEPTH (FT)	=	4.832	4.832	4.832	4.832	4.832

2. WATER QUALITY PARAMETER VALUES * * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.88	4.86	4.84	4.82	4.80	4.79	4.77	4.76	4.74	4.73	4.71	4.70	4.69							
BOD	3.62	3.60	3.58	3.55	3.53	3.51	3.48	3.46	3.44	3.42	3.40	3.38	3.35							
NH3	0.37	0.37	0.36	0.36	0.36	0.36	0.35	0.35	0.35	0.35	0.35	0.34	0.34							
NO2	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18							
NO3	0.73	0.73	0.74	0.74	0.74	0.74	0.74	0.75	0.75	0.75	0.75	0.75	0.76							
PO4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25							

* NOTE* UNITS ARE MG/L* EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)	REAERATION RATE (1/DAY)	CHLOR A/ALGAE RATIO (UG/MG)
K1BOD =	0.30	BOD =	0.0	BOD =*****	K2 = 1.600	RATIO = 75.00
KNH3 =	0.30	ALGAE =	3.00	NH3 = 0.0		
KNO2 =	0.50			PO4 = 0.0		
KCOLI =	1.00					
KRON =	0.0					

TABLE E-8..

* * * * * * FINAL REPORT * * * * * *

REACH NO. 13.0 RCH=HOLSTON RIVER
RIVER MILES 121.6 TO 124.0

1. HYDRAULIC PARAMETER VALUES * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	798.299	798.299	798.299	798.299	798.299
VELOCITY (FPS)	=	0.777	0.777	0.777	0.777	0.777
DEPTH (FT)	=	4.832	4.832	4.832	4.832	4.832

2. WATER QUALITY PARAMETER VALUES * * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.68	4.66	4.65	4.64	4.63	4.62	4.61	4.61	4.60	4.59	4.58	4.58								
BOD	3.33	3.31	3.29	3.27	3.25	3.23	3.21	3.19	3.17	3.15	3.13	3.11								
NH3	0.34	0.34	0.33	0.33	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32								
NO2	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18								
NO3	0.76	0.76	0.76	0.76	0.76	0.77	0.77	0.77	0.77	0.77	0.78	0.78								
PO4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25								

* NOTE* UNITS ARE MG/L* EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS * * * *

DECAY RATES (1/DAY)

KBOD	=	0.30
KNH3	=	0.30
KNO2	=	0.50
KCOLI	=	1.00
KPOM	=	0.0

SETTLING RATES (1/DAY)

BOD	=	0.0
ALGAE	=	3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD	=*****
NH3	= 0.0
PO4	= 0.0

REAERATION RATE (1/DAY)

K2	=	1.600

CHLOR A/ALGAE RATIO (UG/MG)

RATIO	=	75.00

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TABLE E-8

FINAL REPORT

REACH NO. 14.0 ROANOKE RIVER
RIVER MILES 118.0 TO 121.6

1. HYDRAULIC PARAMETER VALUES

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	798.299	798.299	798.299	798.299	798.299
VELOCITY (FPS)	=	0.887	0.887	0.887	0.887	0.887
DEPTH (FT)	=	4.832	4.832	4.832	4.832	4.832

2. WATER QUALITY PARAMETER VALUES

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	4.59	4.62	4.65	4.67	4.70	4.73	4.75	4.78	4.80	4.82	4.84	4.87	4.89	4.91	4.92	4.94	4.95	4.95		
BOD	3.09	3.07	3.05	3.04	3.02	3.00	2.99	2.97	2.95	2.94	2.92	2.90	2.89	2.87	2.86	2.84	2.82	2.81		
NH3	0.31	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.29		
NO2	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18		
NO3	0.78	0.78	0.78	0.79	0.79	0.79	0.79	0.79	0.79	0.80	0.80	0.80	0.80	0.80	0.80	0.81	0.81	0.81		
PO4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25		

* NOTE* UNITS ARE MG/L, EXCEPT FOR FECAL COLIFORM(1000/100ML) AND CONSERVATIVE MINERALS(MG/L*10)

3. AVERAGE VALUES OF REACH COEFFICIENTS

DECAY RATES (1/DAY)

K1BOD = 0.30
KNH3 = 0.30
KNO2 = 0.50
KCOLI = 1.00
KRUN = 0.0

SETTLING RATES (1/DAY)

BOD = 0.0
ALGAE = 3.00

BENTHOS SOURCE RATES (MG/FT/DAY)

BOD =*****
NH3 = 0.0
PO4 = 0.0

REAERATION RATE (1/DAY)

K2 = 2.500

CHLOR A/ALGAE RATIO (UG/MG)

RATIO = 75.00

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FIGURE E-1

STRUCTURE OF THE QUAL II MODEL OF THE HOLSTON RIVER. JULY - AUGUST 1977

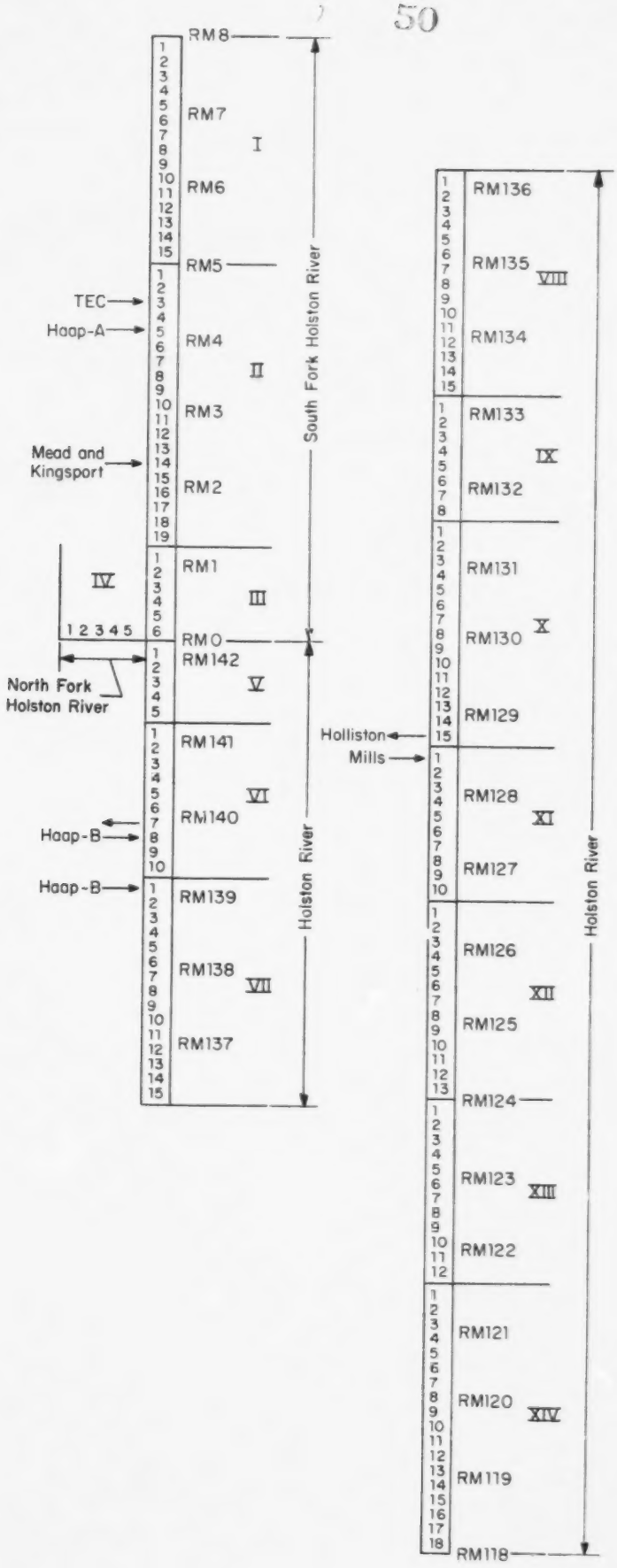

RM8
RM7
I
RM6
RM5
TEC
Haap-A
RM4
II
RM3
Mead and Kingsport
RM2
South Fork Holston River
RM1
III
IV
1 2 3 4 5
RM0
RM142
V
North Fork Holston River
RM141
VI
RM140
Haap-B
Haap-B
RM139
RM138
VII
RM137
Holston River
RM136
RM135
VIII
RM134
RM133
IX
RM132
RM131
X
RM130
RM129
Holliston Mills
RM128
XI
RM127
RM126
XII
RM125
RM124
RM123
XIII
RM122
RM121
RM120
XIV
RM119
RM118
Holston River

FIGURE E-2

DEPTH MEASUREMENTS. HOLSTON RIVER

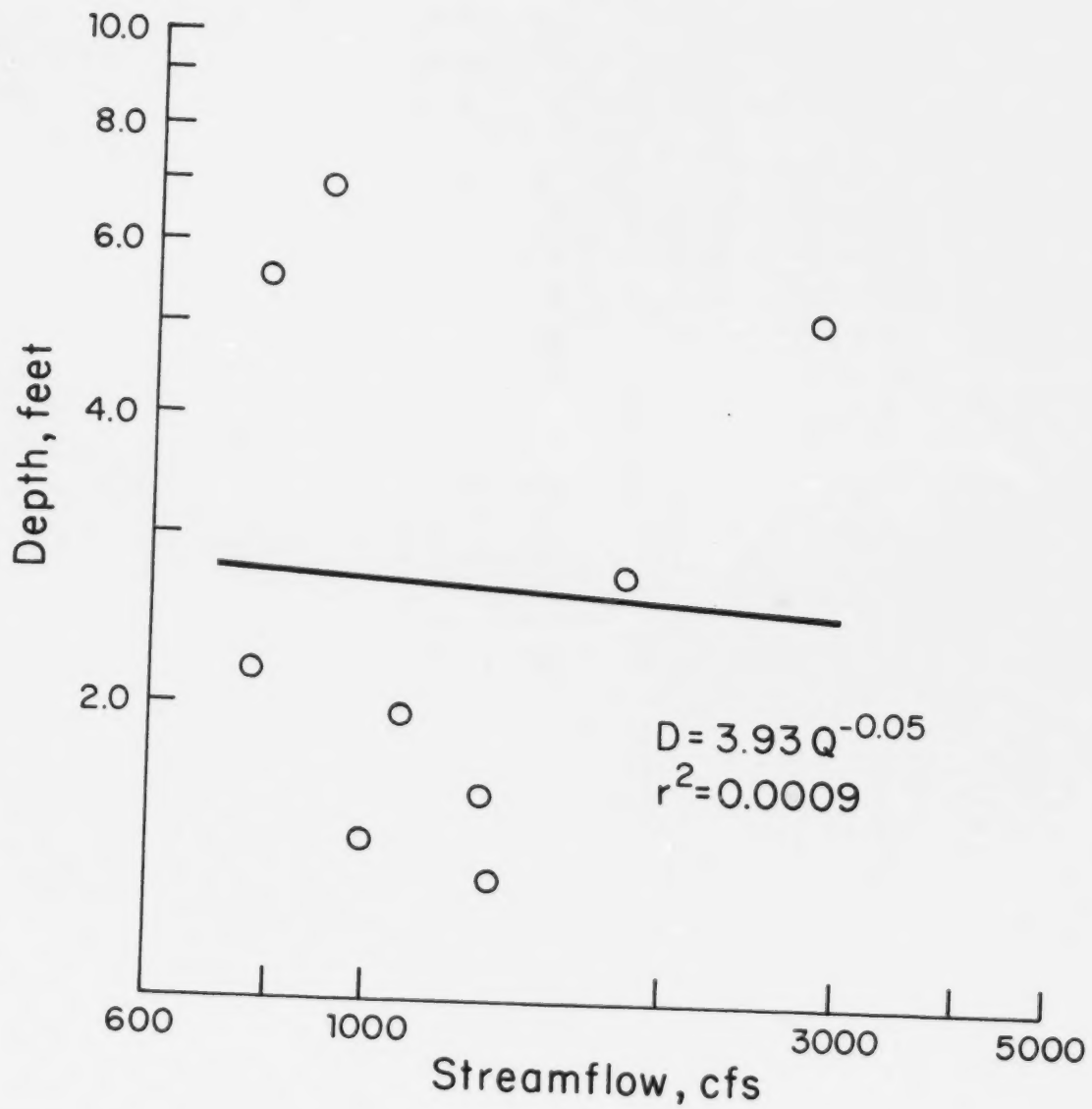

10.0
8.0
6.0
4.0
2.0
Depth, feet
D = 3.93 Q^-0.05
r^2 = 0.0009
600
1000
3000
5000
Streamflow, cfs

FIGURE E-3

DEPTH MEASUREMENTS. HOLSTON RIVER

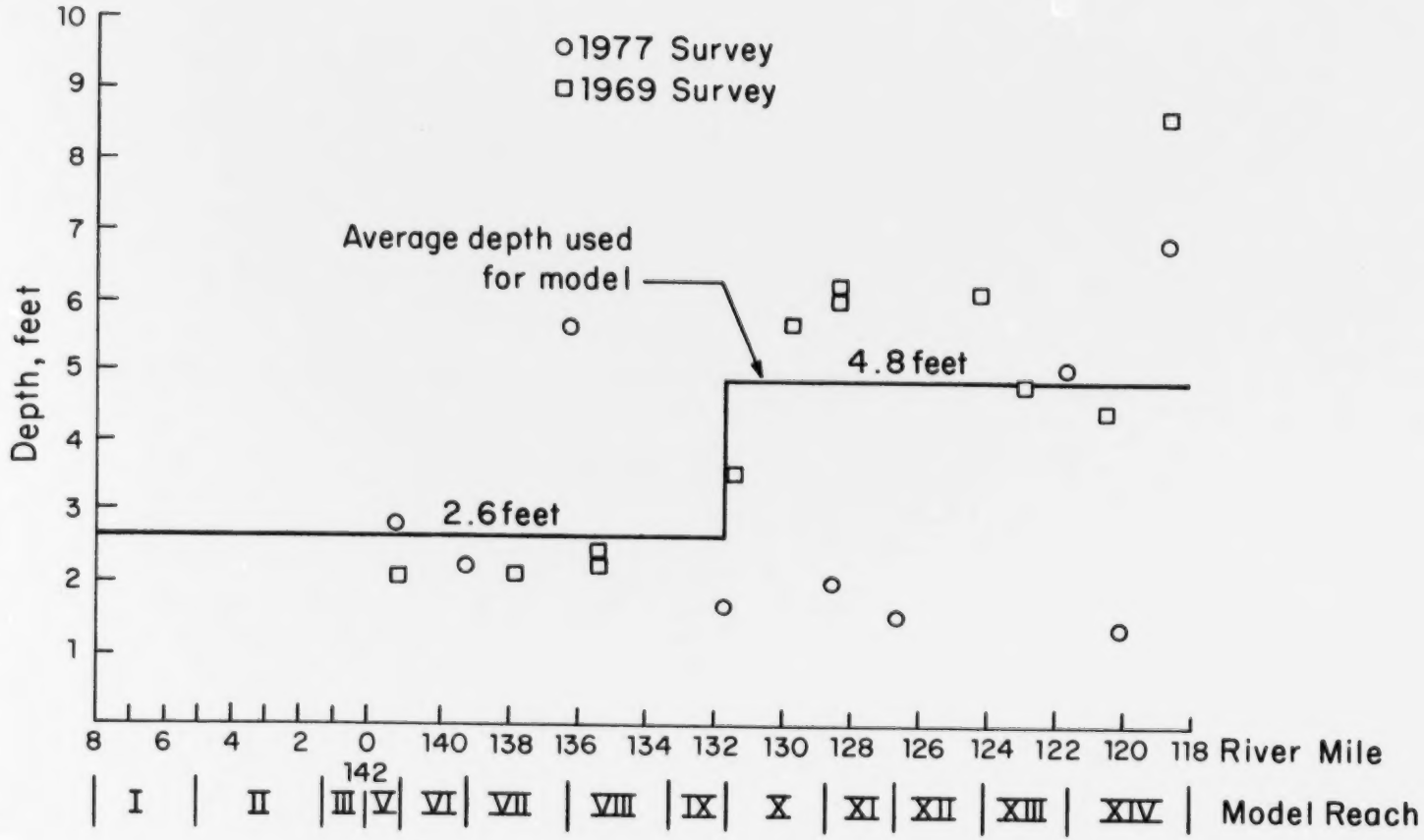

○1977 Survey
□1969 Survey
Average depth used for model
4.8 feet
2.6 feet
Depth, feet
10
9
8
7
6
5
4
3
2
1
8 6 4 2 0 140 138 136 134 132 130 128 126 124 122 120 118 River Mile
142
I II III IV V VI VII VIII IX X XI XII XIII XIV Model Reach

FIGURE E-4

COMPARISONS OF AVERAGE DEPTHS USED IN MODELING INVESTIGATIONS. HOLSTON RIVER

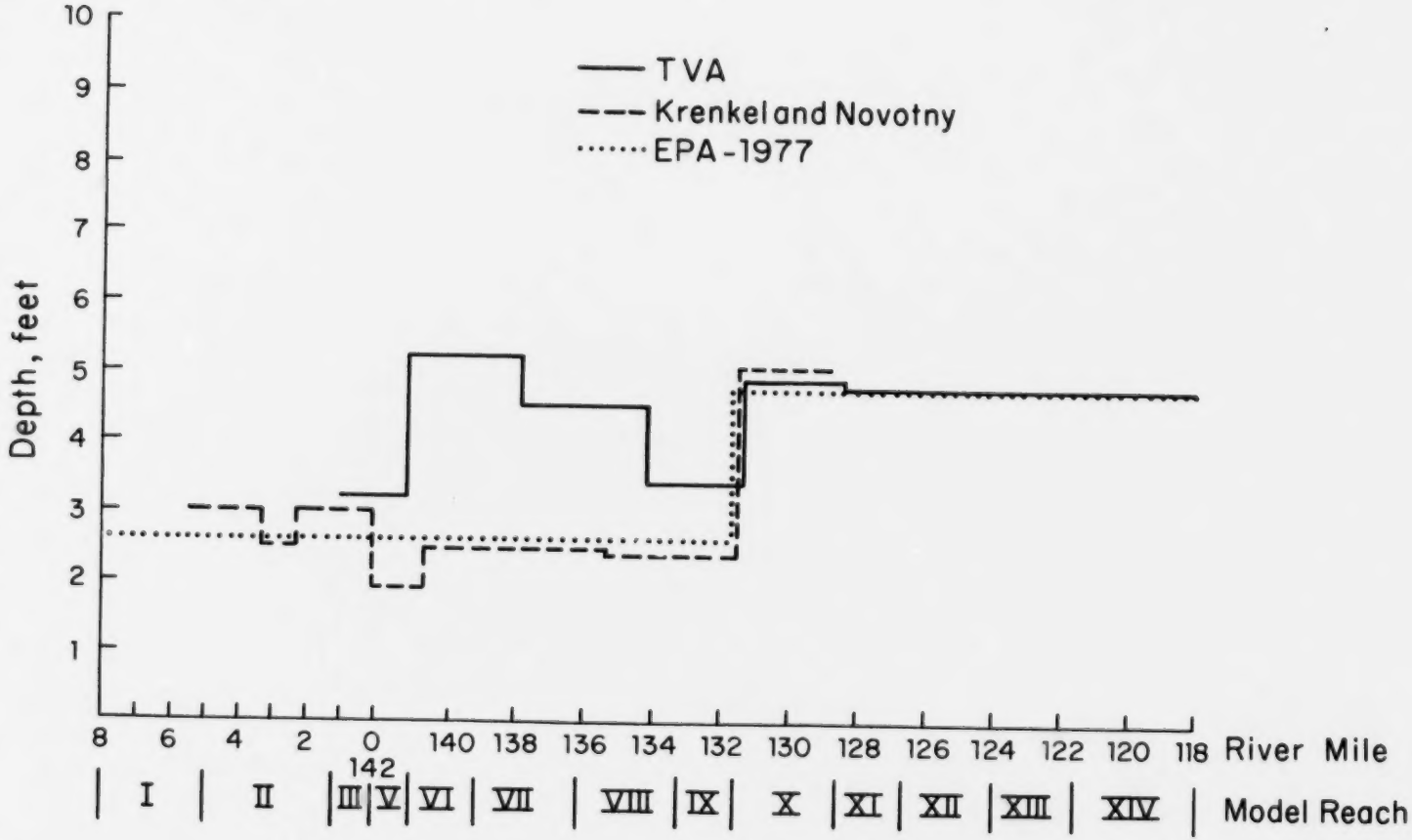

TVA
Krenkel and Novotny
EPA-1977
Depth, feet
10
9
8
7
6
5
4
3
2
1
8 6 4 2 0 140 138 136 134 132 130 128 126 124 122 120 118
River Mile
142
I II III V VI VII VIII IX X XI XII XIII XIV
Model Reach

FIGURE E-5

WIDTH MEASUREMENTS. HOLSTON RIVER.

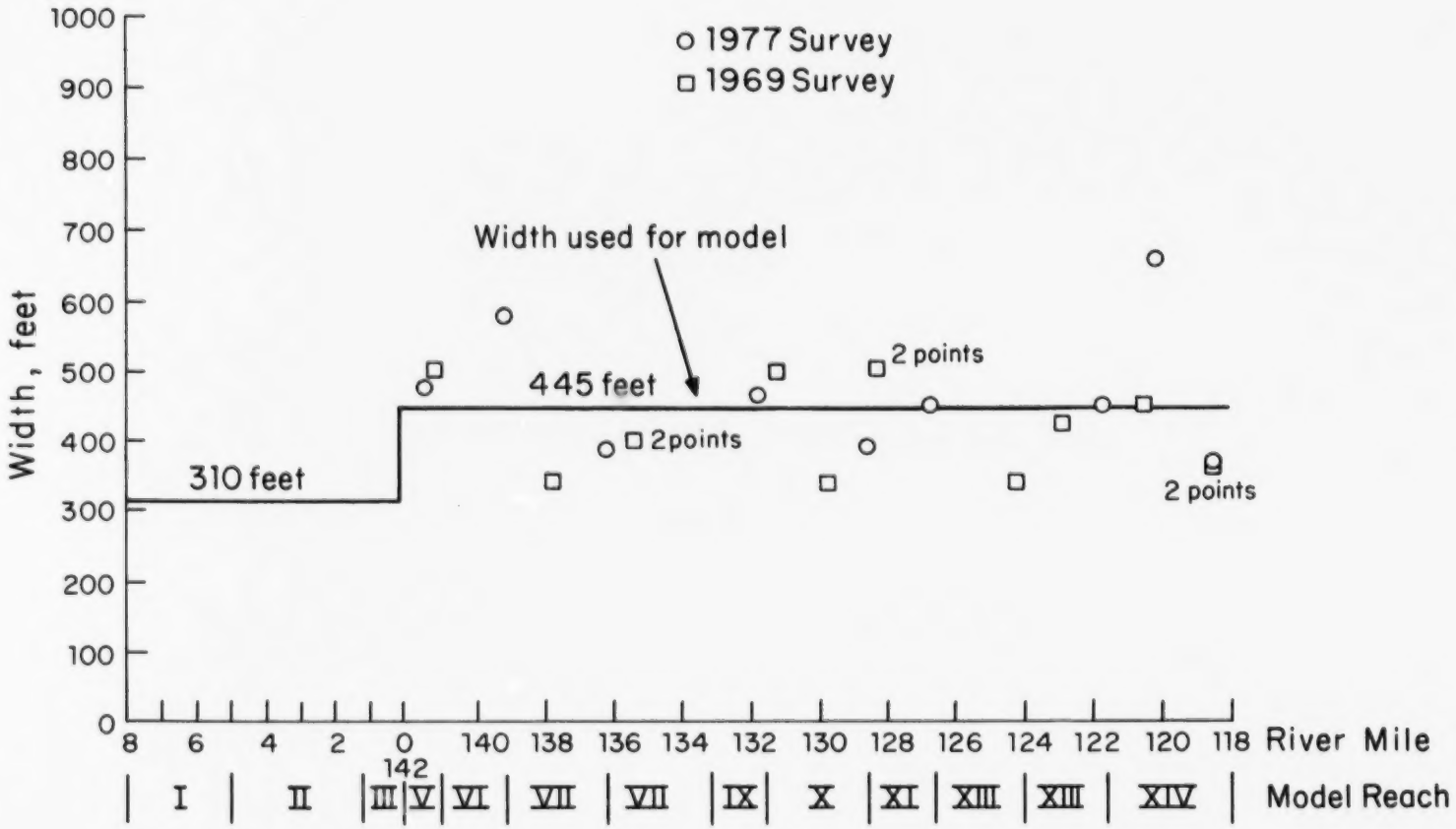
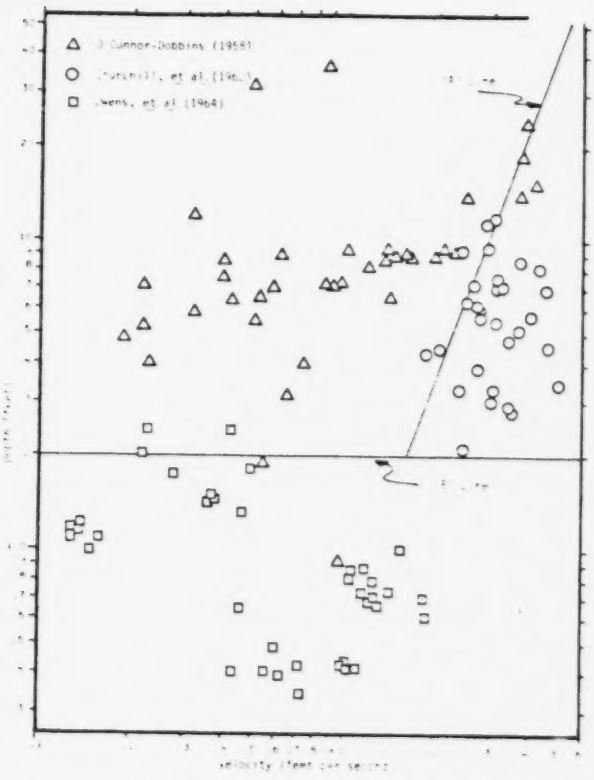
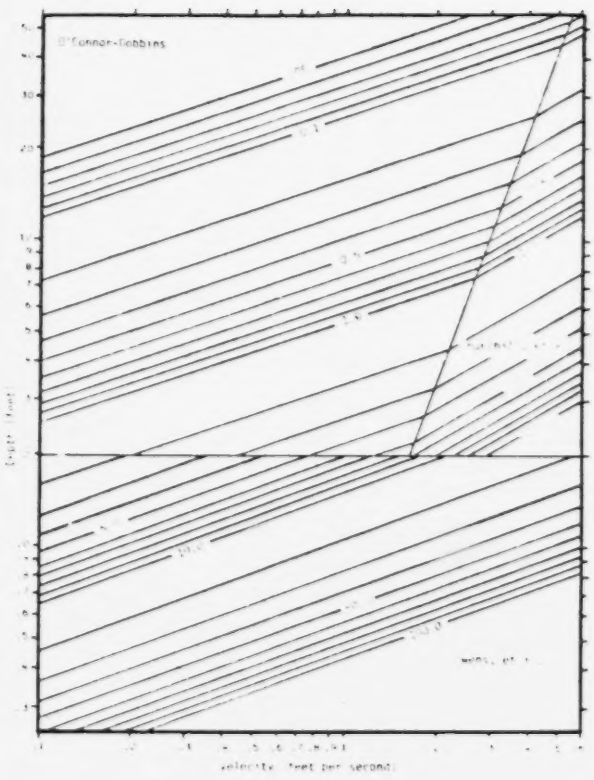

1000
900
800
700
600
500
400
300
200
100
0
Width, feet
○ 1977 Survey
□ 1969 Survey
Width used for model
445 feet
310 feet
2 points
2points
2 points
8
6
4
2
0
140
138
136
134
132
130
128
126
124
122
120
118
River Mile
142
I
II
III
IV
VI
VII
VII
IX
X
XI
XIII
XIII
XIV
Model Reach

FIGURE E-6

REAERATION MODEL SELECTION CRITERIA PROPOSED BY COVAR



Field Data Considered By Three Different Field Series



K_2 vs Depth and Velocity Using The Suggested Method.

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FIGURE E-7

COMPARISON OF O'CONNOR-DOBBINS AND TSIVOLGLOU REAERATION COEFFICIENT PREDICTIONS

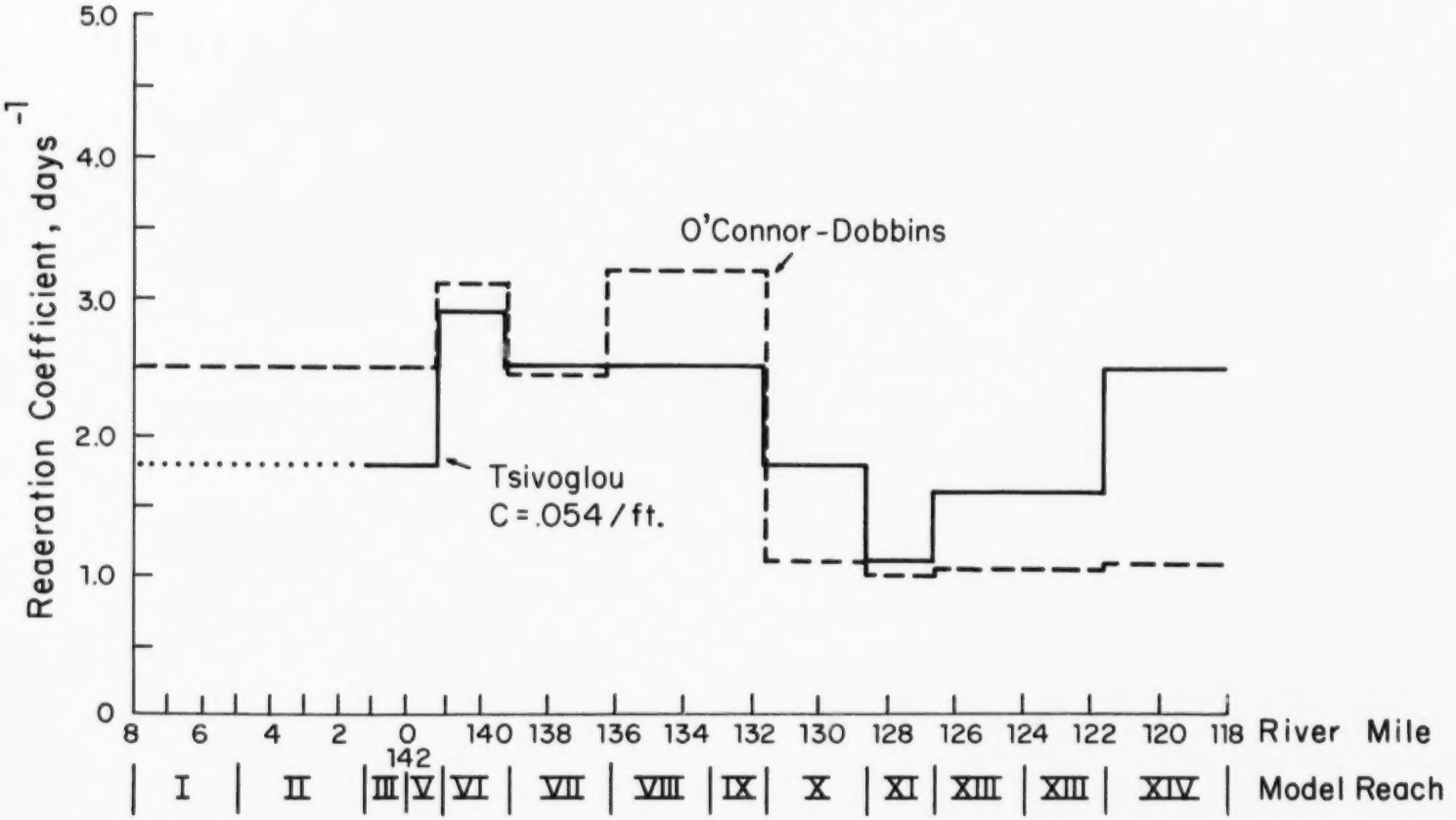

Reaeration Coefficient, days -1
5.0
4.0
3.0
2.0
1.0
0
O'Connor-Dobbins
Tsivoglou
C = .054 / ft.
8 6 4 2 0 142 140 138 136 134 132 130 128 126 124 122 120 118
River Mile
I II III IV V VI VII VIII IX X XI XII XIII XIV
Model Reach

FIGURE E-8

PREDICTED AND OBSERVED DISSOLVED OXYGEN. TSIVOGLOU REAERATION.
HOLSTON RIVER. JULY, 1977

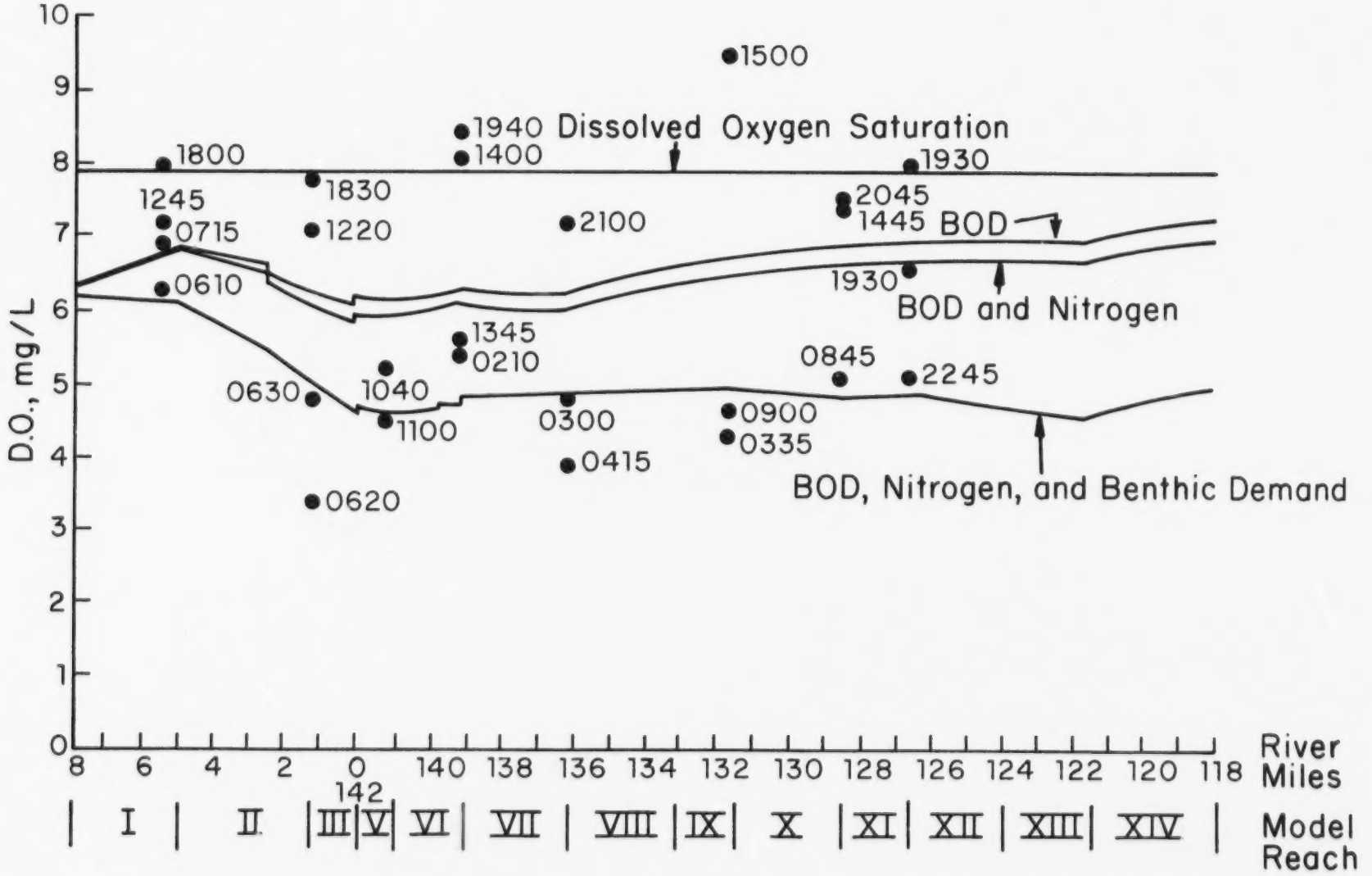

D.O., mg/L
10
9
8
7
6
5
4
3
2
1
0
1500
1940
1400
Dissolved Oxygen Saturation
1800
1930
1830
1245
2045
1445
BOD
0715
1220
2100
1930
0610
BOD and Nitrogen
1345
0210
0845
2245
0630
1040
0300
0900
1100
0335
0415
BOD, Nitrogen, and Benthic Demand
0620
8 6 4 2 0 140 138 136 134 132 130 128 126 124 122 120 118
River Miles
142
I II III IV V VI VII VIII IX X XI XII XIII XIV
Model Reach

FIGURE E-9

PREDICTED AND OBSERVED DISSOLVED OXYGEN. O'CONNOR-DOBBINS REAERATION.
HOLSTON RIVER. JULY, 1977

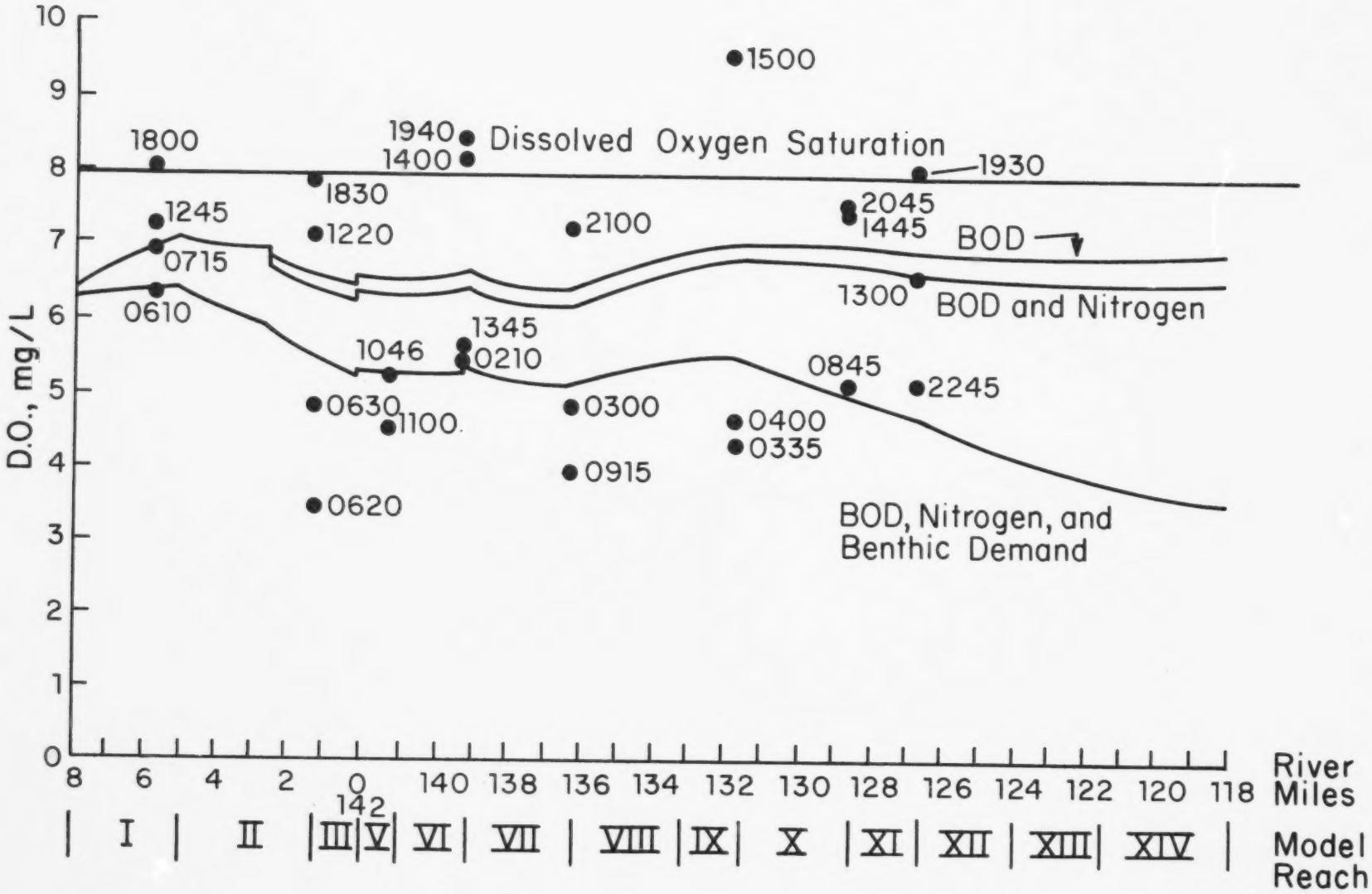

D.O., mg/L
10
9
8
7
6
5
4
3
2
1
0
1500
1800
1940
1400
Dissolved Oxygen Saturation
1930
1830
1245
1220
2100
2045
1445
BOD
0715
1300
BOD and Nitrogen
0610
1345
1046
0210
0845
2245
0630
1100
0300
0400
0335
0915
0620
BOD, Nitrogen, and
Benthic Demand
8 6 4 2 0 140 138 136 134 132 130 128 126 124 122 120 118
142
River Miles
I II III IV V VI VII VIII IX X XI XII XIII XIV
Model Reach

FIGURE E-10

PREDICTED AND OBSERVED BIOCHEMICAL OXYGEN DEMAND. HOLSTON RIVER.
JULY, 1977

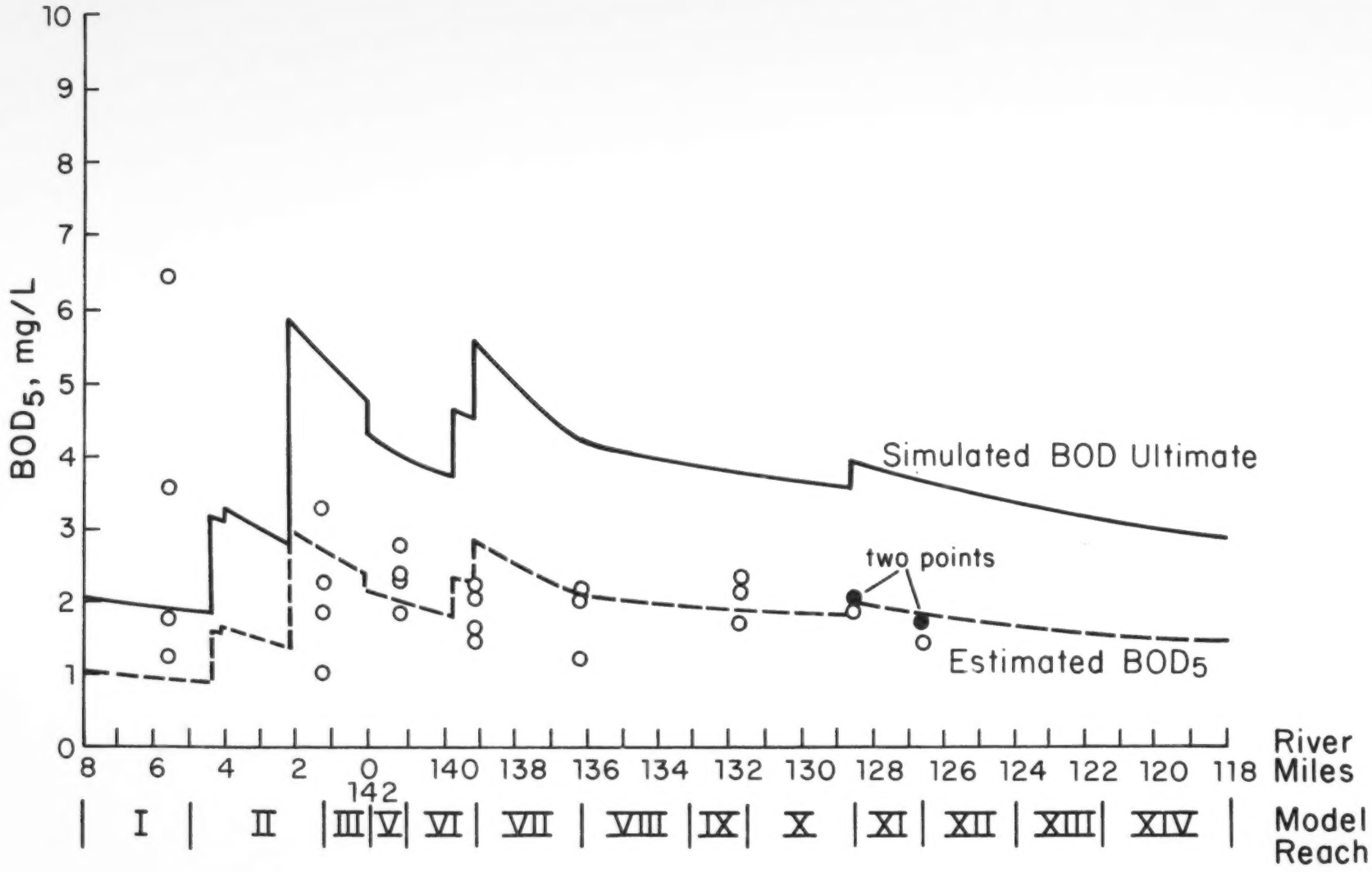

10
9
8
7
6
5
4
3
2
1
0
BOD5, mg/L
Simulated BOD Ultimate
two points
Estimated BOD5
8
6
4
2
0
142
140
138
136
134
132
130
128
126
124
122
120
118
River Miles
I
II
III
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
Model Reach

FIGURE E-11

PREDICTED AND OBSERVED AMMONIA NITROGEN. HOLSTON RIVER.
JULY, 1977

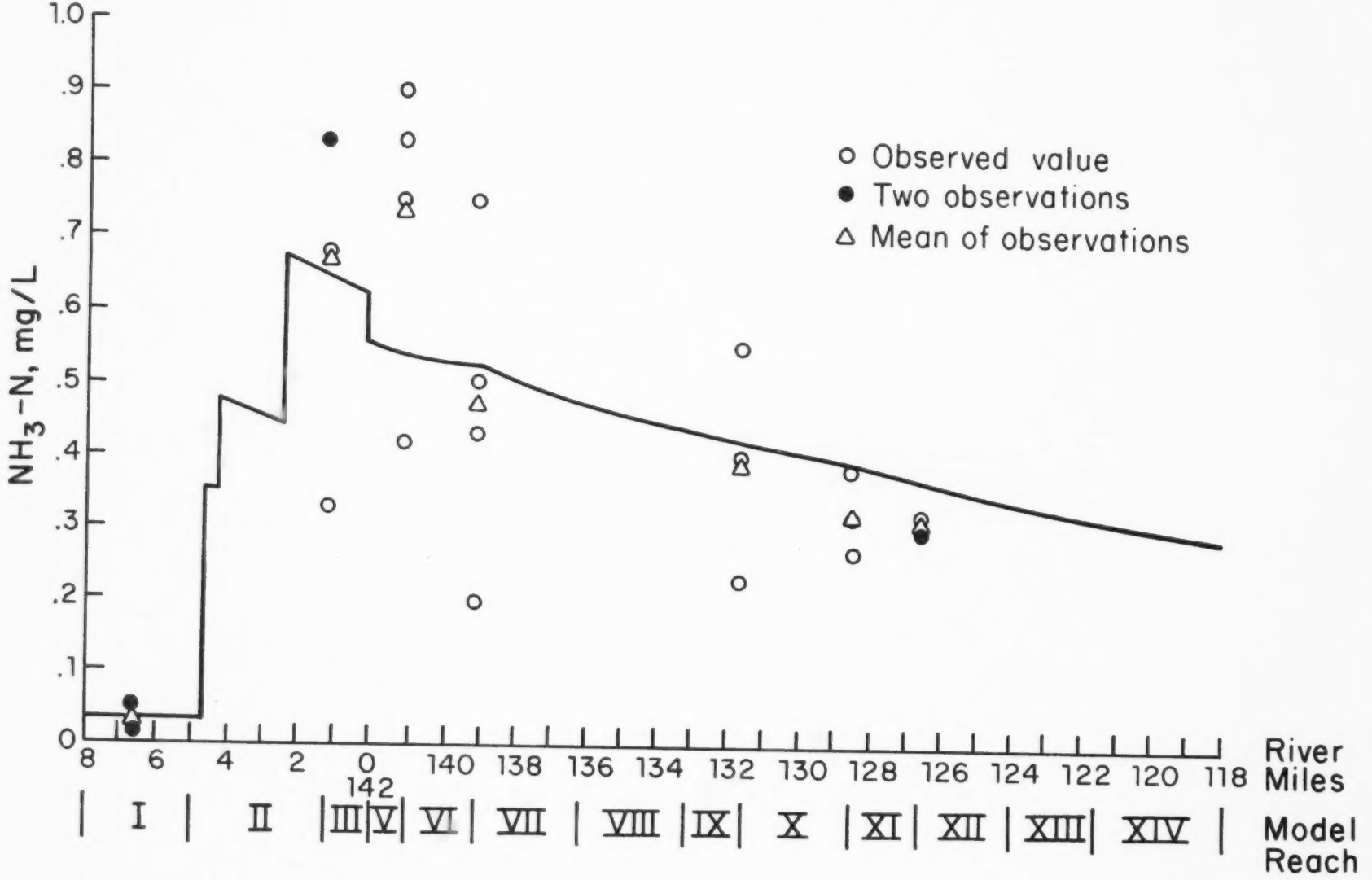

1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
NH_3-N, mg/L
Observed value
Two observations
Mean of observations
8
6
4
2
0
142
140
138
136
134
132
130
128
126
124
122
120
118
River Miles
I
II
III
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
Model Reach

FIGURE E-12

PREDICTED AND OBSERVED NITRITE AND NITRATE-NITROGEN
(MEAN OF OBSERVATIONS). HOLSTON RIVER.
JULY, 1977

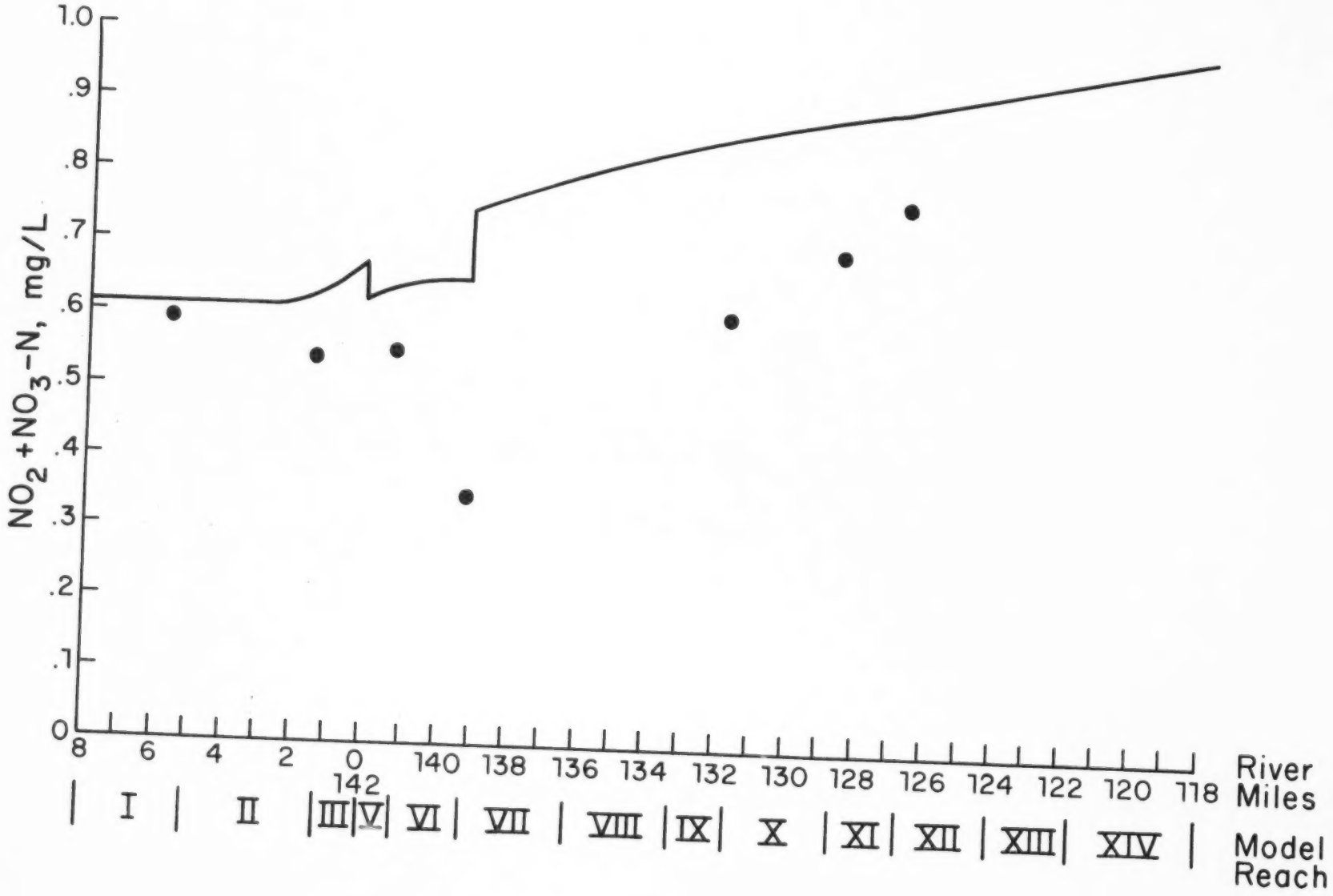
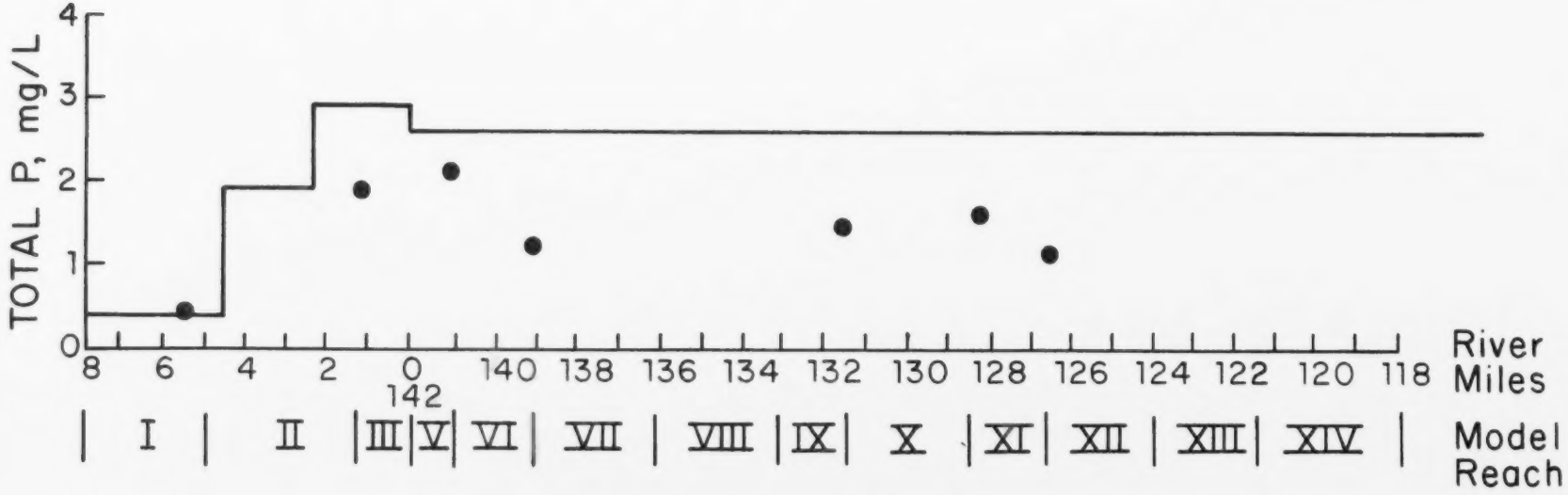

1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
NO_2+NO_3-N, mg/L
8
6
4
2
0
142
140
138
136
134
132
130
128
126
124
122
120
118
River Miles
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
Model Reach

FIGURE E-13

PREDICTED AND OBSERVED TOTAL PHOSPHOPUS (MEAN OF OBSERVATIONS). HOLSTON RIVER.
JULY, 1977



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